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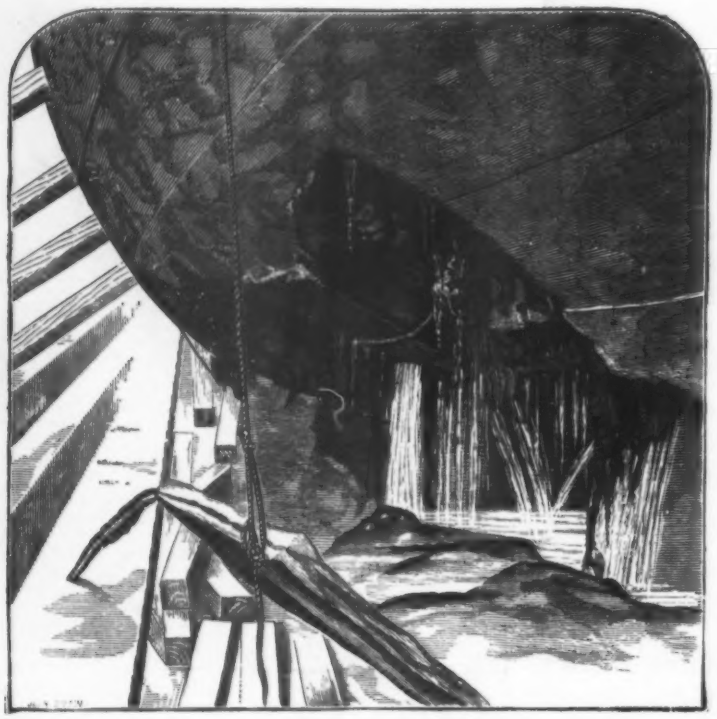
THE BRITISH IRONCLAD SHIP SULTAN.

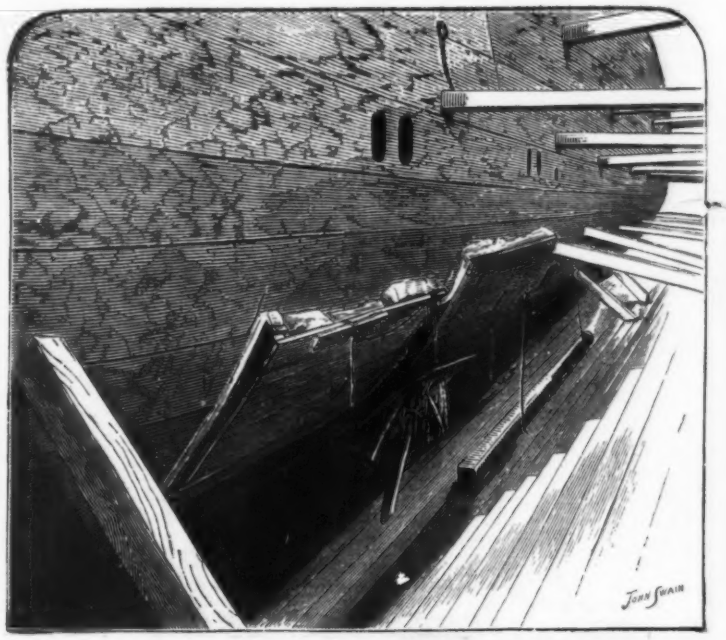
H. M. S. SULTAN.

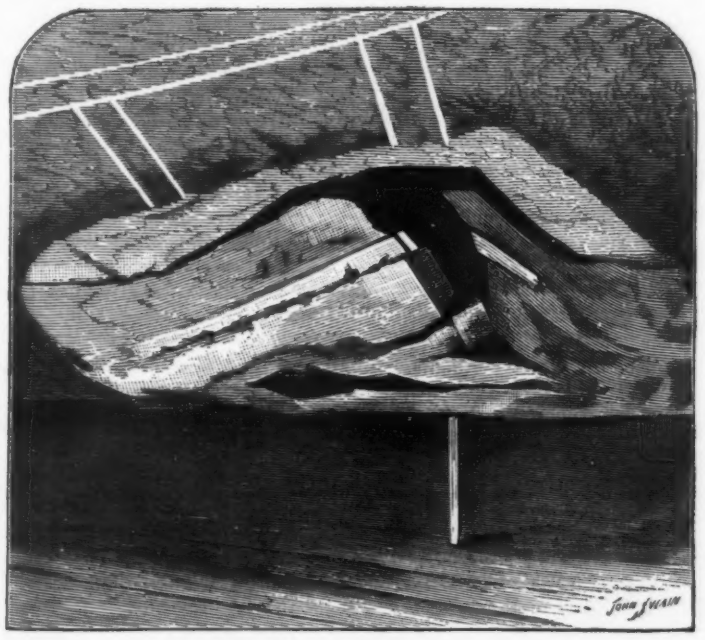
ABOUT a year ago the ironclad ship Sultan, while at torpedo practice, ran upon an uncharted rock in the Comino channel, near Malta. Various unsuccessful attempts were made to raise her. At last the work was intrusted to Messrs. Baghino & Co. Their efforts were crowned with success, and on the 23d of December, 1889, the ship arrived at Spithead, drawing 14 ft. 6 in. We have much pleasure in placing before our readers a series of views, taken from photographs, which illustrate the ship and the nature of the injuries which she received very clearly. The Sultan was completed at Chatham in 1871, eighteen years ago, at a total cost of £374,777, of which the trunk engines manufactured by Messrs. John Penn & Sons, Greenwich, absorbed £76,000. Her displacement is 9,200 tons, and her engines indicate 7,720 horse power. She draws 27 ft., and is 325 ft. long and 59 ft. beam. She carried eight 18-ton muzzle-loading guns, four 12½-ton muzzle-loading guns, and seven 4-ton breech-loading guns, besides a quick-firing armament. The sum paid to the salvage company for recovering the ship and placing her in dock at Malta amounted to £50,000. Notwithstanding this apparently heavy charge and the doubtless large expenditure—not yet estimated—which will be required to make the hull seaworthy, the Sultan is, even in her disabled condition, too valuable a ship to be lost to the country. The heaviest item will be the cost of supplying her with new boilers and machinery. But in any case these would have been necessary, and just before she foundered the Admiralty had drawn up specifications for fitting her with a new set of engines similar in every respect to those for which a contract has been accepted to supply the Hercules. The new triple expansion engines will develop 8,500 horses under forced and 6,000 horses under natural draught, at a total first cost of £82,000.

Notwithstanding the explanations given in our impression for September 13, 1889, it is advisable to say here that the observations of the divers showed that the starboard side from about 50 ft. forward to about 50 ft. aft was indented in all directions, while in some instances the longitudinals had been forced up through the double bottom, whereby the frames, and the longitudinal frames more particularly, had been smashed and distorted. The most important fracture was on the starboard bow, and it was no doubt the damage sustained at this point which prevented the ship from rising upon being lightened. The difficulty of floating the ship was also aggravated by the fact that she lay jammed in between two points of rock, so that the divers were compelled to remove by blasting large portions of the obstruction before they could gain access to the damaged part of the hull. When this had been accomplished, the fissures were stopped by means of wood, canvas, and oakum, pieces of iron plating being worked over the larger rents and secured to the framing by means of hooks and screw bolts, the whole being made water tight by the application of tons of a peculiar cement, which hardened under water to the consistency of very hard putty. She was then pumped out, Messrs. Shand's pump doing admirable service, and floated. She was then towed to Malta, but had to be moored in Bighi Bay for the night. The next morning she was brought to the head of Somerset dock; but, in consequence of her great draught, it was not until she had been relieved of many tons of coal and other impedimenta that she was able to enter. The first thing now was to dry and clean the interior. The decks and hold were covered with black slime which emitted a most disgusting odor, while the paintwork and furniture looked as though the whole had been blackleaded. As soon as the cleaning and drying of the ship had been completed, men were employed to paint and distemper between decks, to temporarily make good defects, and to provide accommodation. Preparations were also made to carry out such repairs as would enable her to proceed to Portsmouth. This was no easy task, as the ship was only a foot from the bottom of the dock floor. The bulk of the crushed and indented plates were sheathed with wood, patches of plating being worked over the holes. When this was completed the ship was floated out of dock, and the blocks raised so as to enable the injuries in the wake of the keel plates to be attended to. She was then redocked and the temporary repairs finished. After having narrowly escaped foundering a second time through a valve having been left open by a careless workman, the Sultan left Malta on the 9th of December, 1889, being escorted as far as Gibraltar by her colleague, the Temeraire, both ships having been lent from the Channel squadron to strengthen the Mediterranean fleet. Arriving at the Rock on the 15th, and parting company with the Temeraire, she left for Portsmouth at 4:30 on the following day in convoy of the Tyne and Seahorse, the former leading by six cables, while the latter followed in the rear at the same distance. The Sultan behaved admirably throughout the whole voyage, an average speed of about 7 knots being maintained, according to Admiralty orders. Soundings were made on board all the way home, but not an inch of water was made during the whole time. The entire operations, from beginning to end, reflect the greatest credit on Messrs. Baghino & Co., and, indeed, on all concerned.

The views on first page show the Sultan before she foundered, and one copied from a photograph taken as she lay on the rocks. The engravings below, from photographs, explain themselves. We may add that the peculiar appearance of one is due to the tangle of long weeds adhering to the ship's bottom.







THE BRITISH IRONCLAD SHIP SULTAN IN DRY DOCK, MALTA.

[Continued from SUPPLEMENT, No. 735, p. 11737.]

SHIP CANALS IN 1889.*

By R. E. PEARY, M. A. M. Soc. C. E.

CANALS IN PROGRESS—AT HOME.

Cape Cod Canal.—The project for a canal across Cape Cod was broached a little over two hundred years ago, and nearly a hundred years ago complete surveys had been made for the work.

It is only within a few years, however, that work has actually been commenced, and it has not progressed very rapidly.

The line of the canal extends from the mouth of Monument River, Buzzard's Bay, to a point south of Sagamore Hill, on Barnstable Bay. The length of the

* From the Transactions of the American Society of Civil Engineers.

canal is 7·6 miles, and the deepest cut is only 25 feet to high water. The proposed section of the canal is 200 feet wide and 23 feet deep below low water. The amount of material to be excavated is about 18,000,000 cubic yards, and the cost is variously estimated at from $3,000,000 to $9,000,000. Time for completion was put at from three to five years. Two miles of the canal are stated recently to be finished to a depth of 15 feet. This canal would shorten the route from Boston to ports south from 70 to 140 miles, and the saving in time for sailing vessels is estimated at an average of three days.

The expected traffic of the canal is put at 4,000,000 to 5,000,000 tons.

The canal has military advantages as important as its commercial ones.

Harlem Canal.—This canal, which will connect the East and Hudson Rivers by way of Harlem River and Spuyten Duyvil Creek, will be about 8 miles long, 15 feet deep and 400 feet wide.

The history of this work dates back to 1874, when General Newton made a survey for the canal. His report was published in 1875, and additional ones in 1876 and 1881. In 1879 Congress appropriated $400,000 for the work, and in 1887 proposals were advertised for and the contract awarded in December of the same year.

The work was commenced early in 1888, and is now in progress. The estimated cost is $2,700,000.

Columbia Canal.—This canal will connect the Congaree and Broad Rivers, S. C. It is 5 miles long, 10 feet deep, 150 feet wide at the surface.

Over a mile of this canal, including the most difficult portion, is already completed. The canal will give Columbia and the Broad River a water outlet to the sea at Charleston.

Cascades Canal.—This canal, now in process of construction around the cascades of the Columbia River, will be 3,000 feet long, and will have two locks, 462 × 80 to 90 feet, with 8 to 24 feet of water.

This canal will give an outlet to the great plain of the Columbia, as yet almost entirely undeveloped.

Nicaragua Canal.—The birth of the idea of a ship canal across the Central American isthmus is practically coincident with the discovery of the new world, as it sprang into existence the moment it was found that there was no natural strait connecting the two seas.

But, though the project was frequently discussed and numerous so-called surveys made, nothing like an accurate survey was made until within the present century.

Immediately the Central American colonies threw off the Spanish rule and gained their independence, the project came prominently to the front. In 1836–37 Mr. Bailey made a partial survey, confined entirely to the western portion of the line, between Lake Nicaragua and the Pacific.

In 1850–51 a thorough survey of a complete route from the Atlantic to the Pacific was made by Colonel O. W. Childs, and plans and estimates presented for a canal 50 feet wide at the bottom, from 78 to 118 feet wide at the surface and 17 feet deep, the estimated cost being a little less than $33,000,000. Colonel Childs' work is of interest as being the first survey made anywhere on the American isthmus which was really deserving of the name, all previous ones being wholly or in part based upon mere reconnoissance, estimate, or even hearsay. A commission of English engineers and capitalists which examined Colonel Childs' plans came to the conclusion that a canal of the proposed dimensions would not meet the requirements of ocean going vessels, nor could the commission see at that time sufficient prospective traffic to make the canal a financial success, and consequently the project was dropped.

When the United States government in 1870–75 undertook through the navy department its comprehensive system of exploration of the American isthmus from Tehuantepec to the head waters of the Atrato, to determine where was the best route for an interoceanic canal, the Nicaragua route was one of the first ones surveyed. Captain Lull, in command of the expedition, presented plans for a ship canal with a bottom width of 50 to 72 feet, a surface width of 106 to 165 feet and a depth of 26 feet, estimated cost a little less than $66,000,000.

In 1876 and 1880 Civil Engineer Menocal, U.S.N. M. Am. Soc. C.E., the engineer of Captain Lull's expedition, revised portions of the route, and, in 1885, radically modified the eastern portions. In the spring of 1887 a concession was obtained from Nicaragua by American capitalists for the construction of a canal, and in the latter part of the same year a large and completely equipped engineering force was sent to Nicaragua to thoroughly resurvey and definitely locate the axial line of the canal. Plans and estimates for a canal with a bottom width of from 80 to 120 feet, a surface width of from 80 to 340 feet, and a depth of 30 feet, based upon the location made by this expedition, were prepared in the latter part of 1888, the estimated cost being about $66,000,000, and the time for completion five years.

The last Congress passed the bill incorporating the company with a capital of $100,000,000, with power to increase to $200,000,000, and the work of construction has already commenced.

The distance from sea to sea by the canal as now located is 170 miles. Less than 30 miles of this distance, however, is actual canal, the remainder being lake, river, and lagoon navigation. In this respect it resembles the Caledonian Canal. The summit level is 154 miles long and 110 feet above the sea. There are six locks. The principal features of this canal are the creation of 64 miles of slack water in the San Juan River by means of a dam and the formation of several miles of lagoon navigation by impounding the surface drainage by a series of embankments. The estimated time of traversing the canal is 28 hours, and the expected traffic when first opened is not less than 6,000,000 tons annually.

The magnitude of the benefits resulting from the opening of this canal it would be impossible to overstate. It will shorten the commercial water routes of the world from 2,000 to 6,000 miles, and the routes between our eastern and western seaboards by 8,000 miles.

Exceptional as has been the success of the Suez and St. Mary's Canals, the Nicaragua Canal will possess all the favoring elements of both in an enhanced degree.

The Suez Canal opened a shorter route to comparatively fully developed countries, and its business has been almost entirely due to the diversion to itself, from longer routes, of an already existing traffic.

The St. Mary's Canal, on the contrary, is the only outlet of a region the development of which has been rendered possible by the canal itself, and it may be said to have created its enormous traffic.

The Nicaragua Canal will open up a direct route to regions that, although they already yield a traffic of 6,000,000 tons per annum (which will immediately seek the canal), may be said to have just begun to develop, and the canal will not only divert this existing traffic to itself, but will in addition create a business the proportions of which it is difficult, if not impossible, to estimate.

The increase in the traffic of the St. Mary's Canal from 1,500,000 tons in 1881 to 4,500,000 tons in 1886, as the result of the development of the region about Lake Superior, may, however, serve as a basis for a general idea of the future traffic of a canal which will practically be to the Pacific Ocean what the St. Mary's Canal is to Lake Superior—its only outlet.

PROJECTED CANALS—ABROAD.

Birmingham Canal.—The rivalry between the great English manufacturing centers, greatly intensified by the construction of the Manchester Canal, will doubtless result in the near future in the construction of similar works for the benefit of Birmingham, Sheffield, Bristol, and other cities. Judging, however, from the numerous projects which have been advanced within the past two or three years for giving Birmingham canal communication with almost everywhere, that city feels the rivalry and the disadvantages of its inland position most keenly, and is likely to be the first to follow the example of Manchester.

The principal projects so far are: a barge canal to the Trent; a ship canal to London, estimated cost $5,000,000; a ship canal to the Mersey, consisting of a concreted channel 60 feet wide, 11 feet deep, capable of passing a 300 ton vessel, and estimated to cost $8,000,000; and a ship canal to the Severn, estimated to cost $6,250,000.

The latter project seems now in a fair way to be put through. The outgoing traffic of Birmingham is stated at 2,000,000 tons, and a toll of four shillings is spoken of.

Great Western Canal.—This canal would be in reality a prolongation of the Birmingham Canal, in the interests of the manufacturing and commercial centers tributary to the Bristol Channel.

The projected route is from Stalford, on the Bristol Channel, *via* Taunton to Seaton, a distance of 62 miles. The canal is to be 125 feet wide at the surface, 36 feet wide at the bottom, and 21 feet deep. Estimated cost, $15,000,000.

The canal would save a voyage of 300 miles round Land's End.

Newcastle-on-Tyne Canal.—The project for a ship canal from the Tyne to the Solway Firth, first talked of some fifty years ago, was again brought forward about five or six years since, and some work done in the way of surveys.

The distance from sea to sea is 80 miles, of which some 12 miles are now navigable by vessels of large size.

It is claimed the canal would offer a convenient short cut for ocean steamers from one coast to the other.

Scotch Canal.—Within the past year a project for a canal from the Clyde to the Forth has been talked of. The length would be 35 miles, and the rise 156 feet. There is at present a 9 foot canal along the route, and it is said there would be no great engineering difficulties to overcome. Estimated cost from $7,500,000 to $10,000,000.

It is claimed that for channel steamers between Ireland or the west coast of Scotland, England or Wales, to the east coast or the Continent, the canal would be of great benefit, shortening the voyage and avoiding the dangerous navigation around the north of Scotland; that it would also open up the coal and oil districts of Scotland, and that vessels from America to the east coast, the Baltic and the Continent would be benefited; but this latter is doubtful.

Important military advantages are also claimed for the canal, as it would permit the rapid concentration of war ships on either coast.

Irish Canal.—The project for a canal across Ireland, between Galway and Dublin, attracted some attention in England in 1883 and 1884.

It was proposed to enlarge the existing canal to a width of 100 feet on the bottom and 200 feet on the surface, and a depth sufficient to permit the passage of the largest ocean steamers. The length would be 127 miles, and there were to be thirty locks.

A preliminary estimate of cost was $250,000,000. Further studies reduced this to $100,000,000. Alternative plans to accommodate vessels of 2,500 and 1,500 tons were estimated at $60,000,000 and $40,000,000 respectively. It was claimed that by using this canal transatlantic steamers to ports on the Irish Sea would save both in time and length of sea voyage. A press comment upon the project at the time was that the "scheme is not much more visionary than the Manchester Canal."

Bay of Biscay-Mediterranean Canal.—This is a project that comes up every little while in France, and which would amount practically to an enlargement of the Languedoc Canal.

One of the proposed routes would follow closely that of the present Languedoc Canal from Bordeaux to Narbonne.

The other starts from the Bay of Biscay at Arcachon, south of the mouth of the Gironde, and runs northeast to the valley of the Garonne; thence along the left bank of that river to Toulouse; thence in a direct line to Narbonne. The total distance is 267 miles. The canal will be 120 feet wide in rock cutting and 147 feet in embankments; width of passing places, 203 feet; depth, 25 to 27 feet. The summit level will be 557 feet above the sea, and the locks will have lifts of 30 feet and over. The deepest cutting will be 168 feet at Naurose. The estimated cost of the canal is $130,000,000, and it would save a voyage of 700 miles around Spain.

North Sea-Mediterranean.—This is one of the most remarkable of great canal projects recently under consideration.

Like most other enterprises of this character, it is old in conception, dating back to the beginning of the Christian era.

It seems to have first taken definite shape about ten years ago in a plan for a canal from Marseilles to Lyons, and thence to Dunkirk. A second route was from Marseilles to Lyons, and thence to Paris and Rouen.

The portion of this last route from Paris to the English Channel seems liable to be executed at a not distant date, a French company having offered within the year to execute the work at its own expense if it is granted a toll of 60 cents per ton on all vessels entering the canal above Rouen.

The proposed canal would be 20 feet deep, and extend along the Seine from Rouen to Paris, 112 miles.

Brussels Canal.—The city of Brussels is agitating the project of deepening her present 10-foot canal to the sea, built in 1836, to a depth of 21–22 feet, to admit vessels of 2,500 and 3,000 tons, at an estimated cost of $4,000,000 to $6,000,000.

Bruges Canal.—The old-time commercial prestige and importance of Burges has been gradually but completely destroyed by the silting up of its communication with the sea, and it is now proposed to construct a ship canal direct to the sea, a distance of 7½ miles. The proposed section of the canal is: bottom width, 66 feet; width at water surface, 203 feet; and depth, 26 feet. The estimated cost is about $5,000,000.

Paris-Boulogne Canal.—This canal is proposed for vessels of 600 to 800 tons. Its width would be 197 to 230 feet, increased to 262 feet at passing places, and the depth 13 feet.

Italian Canal.—In the summer of 1888, Signor Broca completed the survey of a canal across Italy, to save the long journey around Cape Lucca. The line of the canal extends from Fano, on the Adriatic, to near Castro, on the Mediterranean. Length, 180 miles; proposed width, 33 feet; and depth, 40 feet. Estimated cost, $100,000,000, and time for completion, five years. In constructing this canal it would be necessary to drain two lakes. It is claimed that the canal would be of great value to the whole of southern Europe.

Baltic-Black Sea Canal.—Within the past five or six years the project for a ship canal from the Danube, near Vienna, through Moravia and Austrian and Prussian Silesia to the Oder, near Breslau, has attracted considerable attention, and has been carefully discussed at Berlin and Vienna. The distance in an air line is 200 miles and the estimated cost of a canal capable of passing large war vessels is put at about $37,000,000. The project has been reported as entirely feasible, and it is said that a preliminary credit for conducting the surveys has been applied for.

It is proposed that three-fifths of the expense should be borne by Austria and the remainder by Germany.

The number of vessels using the canal, it is claimed, would be three times as great as the number at Suez.

Don-Volga or Black Sea-Caspian.—The route of the long talked of canal, plans for which are said to have been drawn up in the time of Sultan Selim, is to be from Serepta, on the Volga, to Tzaritzine, on the Don, a distance of 53 miles. It will accommodate vessels 230 × 40 feet, of 500 to 600 tons, which it is expected can make the trip in seventy hours.

The estimated cost of the canal is $14,000,000, not including administration, discounts, etc. Of this sum, $8,000,000 is for excavation, $4,000,000 for locks, and $2,000,000 for bridges, buildings, etc. The total excavation is estimated at 35,000,000 cubic yards. The deepest cut is 128 feet.

Perekop Canal.—This canal as projected will cut the Isthmus of Perekop, which unites the Crimea with the mainland, and unite the waters of the Gulf of Perekop and the Azof Sea.

It will be 70 miles long, 65 feet wide and 12 feet deep, and the estimated cost is $40,000,000. It is thought that it can be constructed in four or five years, and it is claimed that it will shorten the voyage between Odessa and Sea of Azof ports 295 to 434 miles, enable vessels to avoid the dangerous navigation of the Straits of Kertch, and greatly benefit the salt, mineral, grain and fuel producing districts of southeastern Russia.

A company is now said to be awaiting Russian sanction to build the canal.

Jordan or Palestine Canal.—The general features of this project were as follows: A canal 25 miles long, about 200 feet wide, and 30 feet deep would be cut from Acre, on the Mediterranean, to the valley of the Jordan, north of Lake Tiberias.

The maximum depth of the cut would be 285 feet.

A second canal 67 miles long, and presumably of the same dimensions, would be cut from the head of the Gulf of Akabah to the south end of the Dead Sea Valley. The deepest cut on this section of canal would be 728 feet.

The valley of the Jordan and the Dead Sea, portions of which are 1,300 feet below the sea level, would then be flooded, obliterating the Jordan, Dead Sea, Sea of Tiberias and several hundred square miles of land, and forming a lake about 147 miles long and 10 miles wide, and the canal would be complete. The total distance from sea to sea is 240 miles. The estimated cost was from $40,000,000 to $100,000,000, and the estimated time of passage as four hours shorter than the Suez route.

Numerous advantages were claimed for this project, among others that it would be the fulfillment of the prophecy in Ezekiel. "Chinese" Gordon was a supporter of it.

As the origin of this project was entirely English, and as it was prominently agitated just at the time when the question of the enlargement of the Suez Canal was being discussed and England was endeavoring to obtain from M. De Lesseps a reduction in tolls and a greater share in the management at Suez, and nothing has been heard of it since, it is open to the suspicion that it was used merely to obtain as good terms as possible.

Syrio-Persian Canal.—The general project for a canal from the Persian Gulf to the Mediterranean was laid before the French Academy of Sciences in the winter of 1886–87, by a French engineer, without, however, any estimate of cost. The line of the canal as indicated that is from Antioch up the Orestes, thence by tunnel through the mountains to the Euphrates, then utilize that river to Babylon, thence by canal to Bagdad, then down the Tigris to the Gulf. It is claimed that this canal would shorten the route between Europe and Asia three days.

Isthmus of Malacca Canal.—The project for this canal was vigorously agitated by the French in Siam

in 1882–83, and in the latter year M. De Lesseps asked the King of Siam for a concession.

This canal would unite the Bay of Bengal and Gulf of Siam near Kraw, *via* the bed of the River Tayona.

Its length would be about 66 miles, and it is claimed it would save 500 miles of dangerous navigation between New York or Liverpool and the ports of China. Estimated cost, $20,000,000.

Ceylon-Indian Canal.—This project is to cut a channel through the island of Ramisseram, lying between Ceylon and India, by which it is said a sea voyage of 300 to 400 miles will be saved.

PROJECTED CANALS—AT HOME.

Panama Canal.—The idea of a canal at Panama is of equal antiquity with that of Nicaragua. The two projects may be said to be twins.

The first actual survey of the Panama line seems to have been made in 1828, but nothing came of it. In 1843–44 M. Napoleon Garella surveyed a line across the isthmus, and a French company was organized, and preparations made to commence the work, but wars in Europe interfered, and the project fell through. In 1875 a line was surveyed across the isthmus by Captain Lull, United States Navy, under orders from the Navy Department, and plans and estimates for a lock canal were presented.

In 1876–77 Lieutenants Wyse and Reclus, of the French Navy, surveyed several lines, and in March, 1878, Lieutenant Wyse obtained a concession from the Colombian government. A company was then formed, with M. De Lesseps at its head, to construct the canal, and after the preliminary arrangements were completed, work commenced in 1881.

Several plans for this canal were discussed, viz., with locks, with a tunnel, and a through cut, the last plan being finally adopted. The length of the canal is 47 miles, the bottom width 22 meters in earth and 24 meters in rock, the surface width 50 meters in earth and 28 meters in rock, and the depth 8.5 and 9 meters. The deepest cut is 386 feet, and the total amount of material to be removed was estimated at first at 46,000,000 cubic meters; later at 105,000,000 cubic meters; and still later, 1885, at 151,000,000 cubic meters, which last figures are probably still below the mark.

The original estimate of the cost of the canal was $120,000,000, the time for its completion eight years, and it was expected that 5,000,000 to 6,000,000 tons of traffic would use the canal.

Under the stimulus of M. De Lesseps' wonderful energy and great prestige the stock of the company was rapidly taken, and great quantities of plant and material were shipped to the isthmus, a magnificent "installation" was put in commission, and the work went merrily on. Almost at the outset, however, obstacles which had been pointed out by prominent engineers were encountered, and the work did not progress as rapidly as had been expected. Several additional issues of bonds were made without dampening the enthusiasm, until in 1886 many intelligent people, who had hitherto believed in the project, became doubtful as to its success. This feeling spread, and became general in 1887, when it was shown conclusively that about $150,000,000 had been expended, and less than one-fifth of the total amount of excavation had been completed, and that the company could raise no more money except at ruinous discount.

To meet this state of affairs the plans were changed provisionally to a lock canal, with locks to be gradually lowered to sea level after the canal was opened. This change very materially reduced the amount of excavation yet to be done, and was not without its effect in restoring confidence in some quarters.

This effect, however, soon wore off, and after a series of desperate financial moves to raise money last summer—among others a grand lottery scheme—the failure of the company to float an additional issue of bonds, even at a ruinous discount, gave the project its death blow, and after a few months of unavailing struggles, it collapsed finally and completely during the past winter, with obligations amounting to over $450,000,000, and after having spent some $250,000,000 in hard cash in the removal of some 50,000,000 cubic meters of material, about one-third the total amount. The laborers employed on the work have been sent home by their respective governments, and the Panama Canal is a thing of the past.

As an engineering work it has not been especially interesting, none of the really serious engineering problems connected with its completion having been touched as yet.

It is interesting, however, as showing the blind infatuation with which the *ipse dixit* of one man may be followed in the face of all facts and experiences, and the results of beginning work without sufficient or accurate information.

It may be taken for granted that the Panama Canal will never be completed.

Delaware-Chesapeake Canal.—During 1879–82 the government surveyed three principal routes for a ship canal to connect the Chesapeake and Delaware Bays, and since then the project has been more or less prominently before the public, and a company was formed to construct the canal, but as yet no work has been done.

Of the three routes surveyed, the one known as the Sassafras is the favorite.

The length of the canal by this route is thirty miles from bay to bay, of which distance fourteen miles will be obtained by deepening and widening streams, and the remaining sixteen miles will be thorough cut.

The proposed section of the canal is: Bottom width, 90 feet; surface width, 171 feet; depth, 27 feet.

No locks except tidal locks. The cost is variously estimated at from $6,500,000 to $11,500,000, and the time for completion is put at four years.

The canal would save 215 miles between Baltimore and New York and other Eastern and European ports, and 286 miles between Baltimore and Philadelphia.

It is anticipated that the canal would attract at least three-fourths of the tonnage of Baltimore, or from 5,000,000 to 10,000,000 tons.

From a military point of view this canal would be of great importance.

Niagara Falls Canal.—Several surveys and plans for a ship canal from Lake Erie to Lake Ontario have been made within the past thirty years, and two powerful causes push the project to the front every now and then: First, the very natural desire to have a canal of our own between those lakes; and second, the fact that the Welland Canal, with its 14 feet depth, is not deep enough to accommodate modern lake traffic, a fact which will be doubly emphasized when the improvements at St. Mary's and St. Clair have been completed and a depth of 20 feet obtained.

A recent project is for a canal 20 feet deep, to accommodate vessels of 3,000 tons. The length is about 25 miles, and the estimated cost $18,000,000. An alternative route of eighteen miles would cost about $1,000,000 more.

This canal seems more than likely to become an accomplished fact in the not distant future.

Florida Canal.—The project for a ship canal across Florida has been more or less continuously agitated during the past ten years or more, and in 1883–84 it looked as if the work would be actually undertaken. A charter was obtained, a company organized, and surveys made, but nothing came of it.

Starting from the St. John's River, just above Jacksonville, the canal would cut across to the Suwanee River, on the Gulf coast. Its total length would be 137½ miles, the deepest cut 143 feet for a short distance, and the proposed dimensions were a width of 230 feet and a depth of 30 feet, sufficient to permit 3,000 ton vessels to pass without sidings. It was expected the canal could be completed in three years, and the estimated cost was $46,000,000.

The canal would enable vessels to avoid the navigation of the Strait of Florida, and would save in distance:

Between New York and New Orleans..500 miles.
" " and Pensacola....600 "
" New Orleans and Liverpool..412 "

Delaware-New York Bay Canal.—This project contemplates the enlargement of the Delaware and Raritan Canal sufficiently to permit its use by large vessels.

This canal, with the Cape Cod Canal, the canal from the Delaware to the Chesapeake Bay, and the Dismal Swamp Canal, would form a grand system of inland navigation, which would offer an almost air line route to the coasting trade between Boston, New York, Philadelphia, Baltimore, Norfolk, and the Carolina Sounds.

Such a system of navigation could not be duplicated in either hemisphere, nor its commercial and military importance be overestimated.

The military advantages of this project have recently been made the subject of a very instructive report by Admiral Luce, U.S.N., in which he points out the facility such a canal would offer for the rapid concentration of war vessels at any point, either for attack or defense, and the complete bar it would present to any effectual blockade of any of our great bays or ports.

Other home projects, comprising some in the earliest embryo stage, some of inconsiderable importance, and some in regard to which it has been impossible to learn more than the name, are as follows:

Lake Borgne Canal.—From Lake Borgne to the Mississippi River; length, 12 miles; length of locks, 350 feet; estimated cost, $450,000. Will save coast trade east of New Orleans a voyage of 265 miles.

St. Clair-Lake Erie.—From Lake St. Clair to Lake Erie, Canadian territory.

Cincinnati-Lake Erie.—Two routes proposed—one from Cincinnati to Toledo, and one *via* Zanesville to Cleveland. Preliminary estimate of cost of enlarging present canals about $28,000,000.

Fresno-San Joaquin River.—Surveys said to have been made, and the canal is to be of size to permit stern wheel steamers to run through from San Francisco. Estimated cost $3,000,000.

Lower Michigan.—From Saugatuck to Detroit *via* Kalamazoo River; length, about 178 miles; width, 112 feet on the surface, 80 feet on the bottom; depth sufficient to accommodate vessels of 1,500 tons; six to eight locks. The canal would give an almost air line route from Chicago to New York, saving several hundred miles.

Upper Michigan.—The project for this canal is undoubtedly the outgrowth of the crowding of the St. Mary's Canal by the rapidly increasing lake commerce.

The proposed route is from Bay Autrain, on Lake Superior, to Little Bay De Noquet, on Lake Michigan. Length, 36 miles; two locks; estimated cost, about $5,000,000, or a little more than the estimated cost of the proposed improvements at St. Mary's. The distance between Duluth and Chicago would be reduced 271 miles.

Lake Erie-Ohio River.—This is a project to obtain a deep water navigation from the great lakes to the Gulf of Mexico. The probable water route would be from Beaver, on the Ohio, 28 miles below Pittsburg, *via* Newcastle and Conneaut Lake to Erie, Pa. Distance, 136 miles; summit, 416 feet above the Ohio and 509 feet above Lake Erie.

Harcourt divides ship canals into three principal classes and one supplementary class, viz.:

First.—Ship canals with locks and a summit level.

Second.—Ship canals passing through low-lying districts, and with only a regulating lock at each end.

Third.—Ship canals without locks, and of world-wide importance.

Fourth.—Ship canals from inland ports to the sea, and lateral ship canals in place of river navigation.

In an engineering sense the division into canals with locks and those without locks would seem to be a sufficient refinement.

A classification based upon the causes which lead to the inception and execution of such canals suggests itself, viz.:

Commercial Canals, originating in the demand of cities or regions, unfavorably situated by nature, for an outlet for their products; or in the struggle between rival cities or states for commercial precedence, or, perhaps, even existence, as the Manchester, St. Mary's and Amsterdam canals.

Military Canals, originating in national military and strategic exigences or ambitions, as the Holstein Canal.

Interocean Canals, originating in the imperative demands of the commerce of the world, as the Suez and Nicaragua Canals.

Commercial canals may, by force of circumstances, become of temporary strategic importance, and military canals are certain to be of more or less commercial utility.

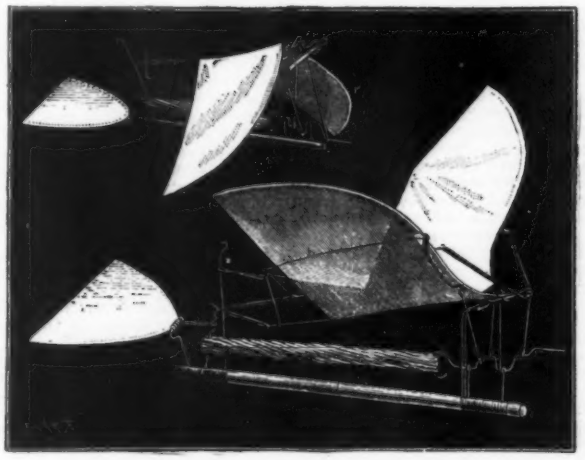
Interocean canals are the highest class. Aiding no one nation at the expense of another, they benefit every country that owns a ship.

Naturally in time of misunderstanding they become of inestimable strategic value to that nation that can control one of them. There are but two locations for such canals—one in each hemisphere, Suez and Nicaragua; one is completed, the other in course of construction.

After making all allowance for the fashion set by the completion of the Suez Canal, and the added impetus given by the commencement of the Panama Canal, eight years ago, to all kinds of projects for ship canals, many of which the recent catastrophe at Panama will cause to drop out of sight, we may safely say that the ship canal has come to stay and to become a powerful commercial and political factor. The next few decades are certain to see wonderful results in that direction.

The completion of the Nicaragua Canal will leave no more worlds to conquer in the class of interocean canals. The universal impetus it will give to commerce, together with the already active tendency in the direction of ship canals to give inland ports a direct and unobstructed communication with the sea, will probably for a time concentrate the activity in ship canal construction to works of that class.

The completion of many of these, and the continued growth of ocean commerce and its ever-increasing demand for shorter routes, will then result in the construction of canals of the character of the Corinth, Italian, Isthmus of Malacca, and Delaware-New York Bay canals, until every sea and ocean route will have been reduced to its minimum length. And though we may hardly expect to reach the state which recent astronomical observations are said to have shown upon our neighbor Mars, where a perfect network of canals, from 30 to 80 miles wide, and some of them 1,000 miles long, appears to traverse the planet in every direction, it perhaps is not too wild a flight to anticipate the time when every maritime nation of importance will have, as one of its most important adjuncts of military offense and defense, a ship canal for the rapid concentration of its huge floating fortresses at different parts of its coast.



A MECHANICAL BIRD.

MECHANICAL BIRDS.

A VERY skillful manufacturer, Mr. Pichancourt, has recently brought out some small mechanical birds which operate very regularly, and one of which we represent herewith. The motion of the wings is brought about by the energy stored up in twisted rubber bands.

In the foreground of our figure are shown the details of the mechanism. In the upper part of the figure the bird is represented on a smaller scale with its wings depressed.

The spread of the wings of this bird is 13 inches. The rubber spring weighs 120 grains and is 5 inches in length. The total weight of the whole is ¾ of an ounce.

The device, in flying, rises slightly and is capable of moving to a distance of 60 feet. Mr. Pichancourt has succeeded in constructing a mechanical bird, of the same kind, of larger size, and which weighs no less than 20 ounces.

Set free by the hand, this apparatus has risen to a height of 25 feet above the ground and fallen at a distance of 21 yards from the starting point, against a head wind of 13 feet per second.

Small mechanical birds of this kind are, of course, but playthings in experimental apparatus; but, when they operate well, as those of Mr. Pichancourt do, they are worthy of being recommended to amateurs of mechanics and aviation.—*La Nature.*

CAST IRON GUNS.

WHILE the experience of the Crimean war forced upon both the English and French governments the necessity of abandoning cast iron guns unless, as in the case of the French type, they were heavily re-enforced with steel, the American war of secession confirmed—at least for the time—United States artillerists in their belief in cast iron for guns of large caliber, whether for smooth bores or rifles. Of the latter class the one most largely used was the Parrot gun, of which 2,000 were cast between the commencement of the war in 1861 and the beginning of 1864. They were made exclusively at the West Point Foundry by the inventor, Captain Parrot, and were cast iron guns of the ordinary form, with a wrought iron re-enforcing ring over the chamber. A. L. Holley, speaking of this type of gun in his "Ordnance and Armor," says: "The 100-pounder and the 8-in. and 10-in. guns are now cast hollow on Captain Rodman's principle, the advantages of which are well known. The bar of iron from which the rings are made is rectangular in shape when straight, but becomes wedge shaped when bent into a coil, thus leaving a space for cinder to be squeezed out when the coil is upset. This feature is directly contrary and an evident improvement upon the Armstrong plan. The hoops are shrunk on without taper, the difference in diameters being $\frac{1}{16}$ in. in 1 ft. They are fastened to the cast iron only by the adhesion due to their tension, and have never been loosened during test or action. When a hoop is to be adjusted, it is heated and slipped over the breech, the gun being slightly depressed. A stream of cold water is then run into the bore, not for the purpose of cooling the hoop from the interior, but to prevent the expansion of the cast iron. The 8-in. rifled gun has thrown spherical smooth shell filled with earth to weigh 52·5 lb., with papier-maché sabots, at an initial velocity of 1,809 ft. per second; charge 16 lb., the same charge that fires the elongated shot of 152 lb. at 1,200 ft. With a charge of 25 lb. the gun fires a 68-lb. to 70-lb. cast iron or steel spherical shot at above 1,800 ft. per second, with about the same strain and no less safety. This gun may therefore be pronounced the most formidable service gun extant. Neither the English 68-pounder nor the French naval gun (6·5 in.), nor the United States cast iron 8-in., 9-in. or 10-in. guns can endure such charges; the Armstrong 110-pounder (7-in.) cannot fire spherical shot, and the United States Navy 10-in. and the new English steel lined 7-in. and 9-in. guns are not yet service guns. The British government has spent (between 1859 and 1864) over £2,500,000 on ordnance and plant, and although it has acquired a gun capable of higher charges for a few hundred rounds, and, what is more valuable, the experience which will enable it to fabricate the best steel cannon without further risk, it is still without a trustworthy naval gun or gun of position."

That this encomium on the Parrot guns was somewhat highly colored is suggested by a statement found in an American book published by a Mr. Wiard in 1863, who stated that work on a number of 7½ in. cast iron rifle guns at West Point was stopped because both in experiment and in service they were proved to be unreliable; nevertheless, the fact remains that the American cast iron guns did admirable service—far better than the cast iron guns either in the French or English navy; this was chiefly due to the superior quality of the American cast irons, some of which withstood as high a tensile strength as 49,000 lb. per square inch, while the average of English gun irons did not exceed 20,000 lb. It is worth noting, however, that during the Crimean war some of the 32-pounders and 68-pounders fired from 2,000 to 3,000 rounds, and were in good condition at the end of this long service; in the London Exhibition of 1851 several cast iron guns were shown varying in size from 6-pounders to 30-pounders; these had been cast at Liège, and had withstood from 2,000 to 6,000 rounds, remaining in a serviceable condition. The construction of cast iron ordnance had in fact up to the year 1864 been developed as far as the imperfect nature of the material permitted; the American war gave a great stimulus to the art; guns as formidable as it was possible to produce them, and also made very quickly and cheaply, were an absolute necessity, and since the Confederates, under the best circumstances, only owned or could produce weapons inferior to those turned out of the Federal arsenals and private factories, it mattered little, except for the protraction of the war, if ranges were short, projectiles comparatively light, and powder charges low; the balance of advantages was still held with the Northern troops, and that was all that was necessary. Nevertheless, the Parrot cast iron rifle and the Rodman smooth bore were formidable weapons; the former ranged in its natures from the 10-pounder weighing 890 lb. and costing £36 to the 10-in. gun weighing 26,500 lb. and costing £900. The length of the former was 70 in., and of thelatter 144 in., the intervening calibers having approximately relative lengths; the powder charges varied from 1 lb. to 25 lb., and the weight of projectile from 10 lb. to 250 lb.; the number of grooves in the 10-in. gun was 15, the depth $\frac{1}{10}$ in., and the rifling, which was on an increasing twist, had a maximum of one turn in 30 ft. These guns were able to withstand very hard usage, as experience in service amply showed; thus a 100-pounder fired a thousand rounds with 10 lb. charges and 100 lb. projectiles; at the end of this service the piece remained in perfect condition, except for a slight enlargement at the bore; a 300-pounder fired 600 rounds with maximum charges before Charleston, and so forth. The Rodman smoothbores earned a famous reputation during the American war, and were indeed marvels of perfection, considering the material of which they were made; the principal calibers were 13 in., 15 in., and 20 in., they were cast hollow and varied in weight from 32,000 lb. to 115,200 lb., the latter (more than 57 American tons) being the weight of the 20-in. Columbiad. The service charge of this gun was 100 lb. and the weight of shot no less than 1,000 lb., the length of bore was 210 in., and the maximum diameter over the chamber, 64 in. The 15-in. Columbiad, throwing a 440 lb. shot with a 50 lb. charge, was, however, the most favorite gun of this class. Both for the army and navy department, the prescribed tests for the material of which these guns were made was that they should have a tensile strength of not less than 30,000 lb. per square inch, while the condition of acceptance of a number of guns was that one, selected from each batch, should withstand, for the smaller sizes, 1,000 rounds, and for the larger calibers of 13-in. bore and upward, 500 rounds. This reduced test was, however, accepted, for all natures, under existing circumstances, and it is stated that many of the 15 in. Rodman guns fired in actual service considerably more than the prescribed 1,000 rounds that formed the test for the smaller calibers. One of the 15-in. navy guns made at this time was fired 900 times at test, with elevations varying from 0 deg. to 5 deg., and with charges increasing from 35 lb. to 70 lb., the weight of shot being in all cases 440 lb.; it was only after the 900th round that this weapon failed. It was with these smooth bore Rodmans that what was probably the last naval engagement to be fought with cast iron ordnance in the English Channel took place between the Kearsarge and the famous Confederate steamer Alabama, on June 19, 1864. Long ranges, such as are attained to-day, were not dreamed of during the American war, and at a time when fighting at comparatively close quarters was a necessity, endurance of guns, weight of metal thrown, and comparatively rapid firing were the useful conditions. Still, remarkable practice was made with the Rodman 15-in. gun throwing 328-lb. shots with 35-lb. charges. The range obtained under these conditions, with very considerable accuracy, exceeded 2,000 yards, while with 50-lb. charges they reached a maximum of 5,730 yards; these results were obtained with spherical shot. It is worthy of note that about the same time Armstrong was producing muzzle-loading smooth bore guns 9·22 in. bore to fire 100-lb. spherical shot; with these about the same range and accuracy were obtained as were given by the Rodman cast iron guns.

Remembering the 110-ton guns with which our most powerful ironclads are now being armed, it is interesting to read in Holley's "Ordnance and Armor" that in 1864, "the standard cast iron gun in England—in fact the standard naval gun—is the 95 cwt. 68-pounder of 8 in. diameter and 113·9 in. in length of bore, and 26·2 in. in diameter over the chamber. Its cost is about 100*l*. It is stated that 100 new 68-pounders have been recently ordered on account of the failure of the Armstrong naval gun as a naval weapon. At the siege of Sebastopol the 68-pounders were on the whole very satisfactory in their range and endurance. Only two of them burst, both at high elevations, and one after having fired over 2,000 rounds. Some of those landed from the Terrible fired as many as 4,000 rounds, usually with 16 lb. of powder, and very rapidly."—*Engineering.*

MUD DOCKS AT VIZAGAPATAM, INDIA.

WHEN a ship is to be docked at the port of Vizagapatam, she is towed up the river from her moorings to near the dockyard. A large ditch of a little more than the ship's length and breadth and deep enough to contain water of the depth of the ship's draught is dug in the mud at right angles to the river. At high tide the water flows into this ditch and forms a basin into which the ship is floated or dragged. Two rows of strong stakes are now driven in across the entrance to the ditch and common palmyra, date, or bamboo mats tied to them. The space between these is filled up with sand and silt, and thus communication is cut off between the dock and the river. The basin in which the vessel is now floating being surrounded by a high mud bank formed by the mud excavated from the dock, the level of the water in the basin is raised by coolies throwing some of the mud of this bank into the basin and thus raising the bottom of the basin, which must in consequence elevate the water in the basin and the vessel floating on it. The vessel is by this process elevated considerably higher than the level of the water in the river or inlet. If the bottom of the ship requires much repair and has therefore to be elevated more than usual, more earth is dug up and heaped high against the sides of the vessel, leaving two or three yards of space in the dock unfilled fore and aft, and then water conveyed thither through a small channel is bailed into the aforesaid spaces. This water also enters under the vessel and elevates it to the height of the mud heaped against it on either side.

Strong beams of wood are by the following process next placed transversely under the ship at two, three, or four different places, varying according to the length of the vessel. At the spot where the beams are to be placed, what is called a mine (ghanee) is dug under the vessel from side to side, coolies working from either side of the ship at the same time until they meet each other under the ship's keel. Three beams, one after the other, are then dragged by a rope tied to the end of each under the keel and laid there one by the side of the other. The same thing is done fore, aft, and midships or in more places if necessary. The mud on the sides of the vessel is then dug away to the level of the surrounding ground and the sides of the vessel calked or otherwise repaired. After this is done—or simultaneously, if the vessel is to be repaired quickly—the mud under the bottom of the vessel is excavated except near the beams, and the ship's bottom repaired, and the beams also if necessary are removed from one place to another to allow repairs where they were originally placed. When the ship's bottom is under repair, several props, consisting of the stumps of palmyra trees, are placed against or slightly under the vessel to prevent her from rolling to a side.

Ordinarily four sets of hawsers are used for undocking the ship after repair, each being coiled into the shape of a cone, the diameter of which at the base is about 5 or 6 feet, and where it touches the vessel a foot or two less. As the coiling is going on the cone is made solid by filling it in with mud. One cone is placed under the starboard bulge forward, another under the same bulge aft, and a third and fourth in corresponding positions on the larboard side. Four cones are ordinarily used at this port unless the ship is of more than three hundred tons burden, when their number is increased according to the length and size of the ship. After this is done the transverse beams are one by one withdrawn, the dock having been first dug to the required depth, and then the vessel, which now entirely rests on these cones, is gradually lowered by withdrawing *simultaneously* from the base of each cone a coil or fake, by which the four cones supporting the vessel bodily subside at a low speed and the vessel along with them. The cross bund being now removed, the water from the inlet flows into the dock and floats the vessel at high tide.

The docking and undocking of a vessel of two hundred tons ordinarily costs about Rs. 50, including the rent of the dock and the props and beams; and the cost increases in proportion to the size of the vessel and its draught.

Vessels of four or five hundred tons burden have been built and undocked at Vizagapatam in the manner set forth above, such as the Gallant Neil, the Lady Sale, etc.

If on account of any extraordinary season a sufficient quantity of water does not flow into the dock, which is very rare, four or five large casks rented or belonging to the vessel are tied fore and aft at low water, or if large casks are not procurable a large boat or canoe is tied on, when filled with mud, and this mud being gradually removed, the rising of the canoe or boat helps in setting the vessel afloat.—*Indian Engineering.*

THE HUDSON'S BAY RAILWAY.

IN the course of a recent speech in the Senate in advocacy of the immediate enlargement of the St. Mary's River and canal—which is the only outlet to the navigation of Lake Superior—Senator Davis, of Minnesota, gave the following:

It greatly concerns our own interest in another respect that we promptly second the endeavors of personal and corporate enterprise by at once increasing the capacity of the improvements of the St. Mary's River, so that it will not be for the interest of the people of Canada to develop or for the interest of our own Northwestern States to encourage the opening of a new outlet to the markets of the world, an outlet wholly outside our own boundaries, and which, while it will benefit greatly a large portion of our own country, we cannot in the least degree control. I refer to the outlet to tide water on the western coast of Hudson's Bay. This is no mere theory; it has been a demonstrated fact for more than two hundred years.

The country north of the international boundary up to the fifty-sixth parallel of north latitude and east of the Rocky Mountains, to and including the province of Manitoba, contains about 100,000,000 acres, a large portion of which is well suited to the production of cereals. The northern portion, known as the Peace River district, owing to the depression of the Rocky Mountains, has quite the same climate as the southern part and is equally fertile. Immigration is invading this immense region, and the time is not far distant when it will be enormously productive.

From the Minnesota line to Churchill, on the western shore of Hudson's Bay, the distance is less than 800 miles. Of this distance more than one-third is occupied by Lake Winnipeg, having a navigable area nearly equal to that of Lake Erie. It drains with its tributaries a basin of about 400,000 square miles. Churchill has an excellent harbor. It is as near to Liverpool by the way of a ship as is New York City. It is nearer to Liverpool by 64 miles than is Montreal. As to the distance from the city of Winnipeg to Liverpool, the saving is therefore substantially the whole distance from Montreal to Winnipeg. It is equal to 1,291 miles by way of Lake Superior, or 1,698 miles by way of Chicago. From Winnipeg south to the international boundary line at Gretna is 69 miles. This is the shortest possible route to tide water for the great wheat-growing regions of the Northwest, both in the United States and Canada.

It has been estimated that the saving in the transportation of wheat by this route would be such as to add a profit of $3 on every acre of wheat produced in North Dakota and Northwestern Minnesota.

The Canadian government has not been insensible to these facts. It has adopted measures looking to the construction of a railroad to Churchill. In 1878 it sent out one of its vessels, the Neptune, from Halifax, with a corps of most competent observers, to ascertain the navigability of Churchill and other harbors on the bay through the straits of Hudson. It was found that ice forms in the harbor of Churchill on an average about the middle of November and breaks up about the middle of June, thus giving one hundred and fifty days' navigation in each year for large ocean steamers. The canal at the St. Mary's River for the five years ending with the year 1888 has been open for an average of about two hundred and twenty days in each year.

It is stated in a paper read before the Royal Geographical Society, by Commodore Markham, that the temperature of the water in Hudson's Bay is 14° higher than that in Lake Superior. The bay has been navigated for two hundred and seventy years. The Hudson's Bay Co. was incorporated in 1670, and from the time it commenced its operations in this portion of North America until about the year 1864 it sent out its men and supplies and took out its furs by ships into Hudson's Bay. Moose Factory, on the extreme southern shore, was visited annually by a ship from the year 1735, with the exception of the year 1779. This commerce was carried on by means of sailing vessels, without the aid of adequate charts, or of any lighthouses or artificial harbor facilities. Specially constructed steamships of great power and strength and of large tonnage could easily move each season the grain, cattle, and mineral products of the new Northwest, with adequate return freights to supply the wants of its people.

I submit these considerations because they are cogent reasons why we should act upon the pending subject with promptness and liberality. The tendency of transportation is at present over the east and west route by way of the Great Lakes and the Canadian and American canals. It ought to be generously and speedily encouraged. It draws these great commonwealths closer to each other along their entire length. The opening of another route whose tendency will be repulsive to political and commercial intimacy will be the certain result of provocatory or retaliatory treatment by us of this great subject of our relations with Canada.

JOHN ERICSSON.

By Prof. C. W. MACCORD.

JOHN ERICSSON was born July 31, 1803, in the Swedish Province of Vermland.

His father, Olaf, was a mining proprietor; his mother, Sophie, the daughter of an iron master; thus his early surroundings were well calculated to develop his mechanical tastes, of which he gave evidence in his very childhood. At the age of nine he had learned by observation the use of drawing instruments, and in less than a year after he began the career as a designer

and constructor which ended only with his life. Making for himself compasses of birch wood, with needles in the ends of the legs, and converting a pair of tweezers into a ruling pen, he drew in detail the plans for a windmill and a pumping engine of his own devising. These drawings he colored with brushes which he made of hairs purloined from his mother's sable cloak; and finally he built and set up the small machines themselves.

These things coming to the notice of Count Platen, then President of the Gotha Ship Canal, the result was that, when a little over twelve, young Ericsson became a cadet of mechanical engineers, and at thirteen was made a leveler upon that important enterprise. At fourteen he had charge of a section, at the head of 600 men, an attendant being detailed to carry a stool, upon which he stood to bring his eye to the height of the leveling instruments; and in his leisure time he made drawings of every machine and implement used in the construction of the canal.

In 1820 he entered the Swedish army as an ensign, soon rose to be a lieutenant, and shortly afterward passed with distinction a competitive examination for an appointment on a survey of Northern Sweden. While engaged on this work he not only made the drawings for a book on canals, but invented and made a machine for line engraving, by means of which he, within a year, completed a number of large copperplate engravings of superior merit.

In 1826 he went to England on leave of absence, in order to introduce a "flame engine," which had worked successfully with the shavings of Swedish pine, but was not adapted to the use of English coal. Overstaying his leave, he became technically liable to the penalties of desertion, but this was overcome through the interest of "friends at court," the result being that instead of resigning his commission, as has often been erroneously stated, he was practically given an indefinite leave of absence, with a promotion to the rank of captain, which he has ever since retained.

He never returned to his native country, but remained in England for thirteen years, during which time he produced nearly forty different machines and inventions, all of high merit and some of great importance. Among these may be mentioned a deep sea sounding lead, until recently in use all over the world, a marine surface condenser, a machine for cutting files, improvements in tubular boilers, a system of artificial draught produced by centrifugal fan blowers, now universally employed. During this period, also, he built, at the early age of twenty-six, the first steam fire engine; and in the same year he planned and built, in seven weeks, a locomotive of most original and elegant design, which showed the inventor's prescience of future possibilities of high speed traffic, by attaining the then phenomenal speed of nearly fifty miles an hour. These two things alone would have sufficed to give him a high place on the roll of famous engineers.

Ericsson is recognized in France as the father of screw propulsion. Without pretending that he was the first to conceive the idea, it is beyond dispute that to him, more than to any other man, is due its practical commercial success. While others were endeavoring to obtain the requisite velocity of rotation by means of gearing, he threw that complication to the winds, and coupled his engines directly to the shaft. But finding his efforts in this direction coldly received in England, he came, in 1839, to America, where he made his home during the remaining half century of his life.

Here, in 1840, he still farther distinguished himself by designing the machinery of the Princeton, the first naval screw steamer. For the first time a war steamer had her machinery and boilers below the water line; her semi-cylindrical engines were of a novel design and beautiful proportions, and gave her the speed, at that time unusual, of 13½ knots; she had, also, a telescopic smoke stack, centrifugal fans for draught and ventilation; and was provided with a 12-inch wrought-iron gun, re-enforced by a band shrunk on the breech, with a most ingenious and effective device for taking up the recoil, an automatic gun lock, and an instrument for determining the distance of the enemy, all of Ericsson's invention. To the deep and lasting shame of this country, his bill for services rendered in the planning of this vessel, for a long time the pride and glory of its navy, has never been paid. The Princeton dictated reconstruction to the navies of the world; and the merchant service is equally indebted to his energy and perseverance, for the introduction of the screw propeller. This was from the first duly appreciated and favorably received on this side of the ocean; in four years after his arrival he had applied it to more than forty vessels; what is and has long been known as the "Delamater screw" is, in reality, Ericsson's.

The "flame engine" alluded to was the precursor of the caloric engine, which, in 1833, he brought out in England, where it attracted much attention in scientific circles, but did not achieve commercial success. It was not, however, abandoned; his efforts to improve it were continued in America, where, in 1854, a trial of a vessel of 2,000 tons, fitted with the new motor, proved that on a large scale it could not compete with steam. This failure seemed, somehow, to be remembered by those who forget the success with which he adapted it to use upon a small scale; receiving the gold and silver medals of the Rumford prize for the "domestic caloric engine," of 1858, which met with ready sale by thousands.

Like many other industries, the manufacture of these engines, which was rapidly extending, was interrupted by the breaking out of the civil war, and the great engineer once more turned his attention to warlike matters. He had previously, in 1854, sent to Louis Napoleon a design for an iron-clad vessel with a revolving turret, of which the French emperor had taken no notice. A wholly different and much better vessel, the historic Monitor, was begun by Ericsson in October, 1861, and fought her great battle on March 8, 1862. This success led at once to the construction of fleets of turreted vessels, of various sizes, the complete plans for many of which were furnished by him, including the Passaic class, the Dictator and the Puritan. Immediately after, he planned and built the machinery for the frigate Madawaska, and the gun carriages for the 15-inch guns of the ram Dunderberg. Various new forms of the caloric engine were next in order—but, in 1869, the insurrection in Cuba again called his naval skill into play, and he furnished designs for the machinery of thirty gunboats for the Spanish government, under unusually exacting conditions, since no boat would be accepted which drew *one inch* of water more than the stipulated amount; he also designed for them peculiarly elegant and very successful pivot gun carriages. Carriages similar in construction were subsequently designed and built by him for coast defense. In 1872 and 1873 he brought out a system of movable torpedoes, operated and steered from the shore by means of compressed air, and about the same time constructed several experimental hot air engines, of which the practical outcome was the familiar "caloric pumper," of which thousands were made at the Delamater works. In 1878 he built the Destroyer, a small vessel fitted with a gun in the bow for the submarine firing of torpedoes, a subject to which he had given much attention; at first he used compressed air as the means of propelling the missile, but, the government subsequently providing the appliances for experimenting on a different mode, he used a charge of powder instead.

In the meantime he had at intervals for years been conducting experiments on a most liberal scale upon the radiant heat of flames of molten and incandescent metal, and upon the solar temperature; and had constructed both steam and hot air engines whose only fuel was furnished by the rays of the sun. For the purposes of these experiments he had devised and made a great number of original and ingenious machines and instruments; and withal he found time to make laborious computations based upon the results of his observations, to contribute many articles to various scientific journals, and to give much consideration to the condition of the lunar surface and the causes tending to retard the earth's rotation.

During the last few years of his life, in addition to continued experiments on solar temperature, he had constructed a high-speed engine for use in connection with electric plant, and bestowed much labor upon a high expansion steam engine and still another form of caloric engine, neither of which last were completed to his full satisfaction at the time of his death, which occurred on the 8th of March, 1889.

The above outline is necessarily a very meager one; the briefest possible descriptive catalogue of all the work executed by this remarkable man would fill a much larger volume than the *Indicator*. Mention should, however, be made, as further illustrating his versatility, of the instruments which gained for him a prize medal at the World's Fair at London in 1851. Besides the distance instrument and deep sea lead, already mentioned, these comprised hydrostatic gauges for measuring the compression of liquids under pressure small and great, an alarm barometer, a pyrometer, a rotary fluid meter and a reciprocating fluid meter, of which the last had already been adopted by the Croton Aqueduct Department.

For want of space, no attempt has been made to enumerate the different designs of caloric engines, of which he built a great number for special purposes besides those which came into general use; nor a still greater number of engines, marine and stationary, using steam alone, saturated and superheated, as well as the latter mixed with air. Of these a partial list may be found in his "Contributions to the Centennial Exhibition." This book, though relating solely to work carried out by him upon American soil, is a large and beautifully illustrated volume, the preparation of which must of itself have been a task of no small magnitude. It has been criticised by the envious as exhibiting vanity; it certainly shows that he had accomplished what any man might well be vain of having done; and yet it does not tell the whole. Nor would any catalogue, however complete, give an adequate idea of the labor which he personally performed. His method of work was peculiar in this, that he left far less than is usual among constructing engineers for his assistants to work out; he was fastidious in regard to details, of which his arrangement was masterly; as a draughtsman it is questionable whether he ever had a rival, either in wealth of expedient or in rapidity of execution; and this facility, combined with a most unusual power of continuous application, enabled him to do with his own hands far more than the ordinary proportion of detail work.

Captain Ericsson was a man of striking presence; Of this he was fully aware and, to tell the truth, somewhat vain; his brown hair and whiskers were never permitted to grow gray. His complexion was fair, but bronzed, as if by exposure; his features were somewhat stern in repose, but when animated, were lighted up by a genial smile, and a merry expression in eyes which, clear and blue, could upon occasion be equally expressive in anger.

He was not tall, being about five feet nine inches in stature; his head was large, well poised, and firmly set upon broad and well developed shoulders; his whole figure was compact and firmly built, and his physical strength was prodigious. Of this he was not vain, but he husbanded it with jealous care; outdoor exercise, when in health, he seldom took, except in the form of a long walk in the evening; but his habits, during at least the last thirty years of his life, were as regular and his diet as temperate as though he were an athlete in training, and his day always began with a cold bath, followed by dumb-bell exercise.

His voice was deep and powerful, and he spoke the English language with faultless purity, but with a decided, though not unpleasant, foreign accent. Indeed, although he was a most patriotic citizen of America, he never forgot his native land. As soon as the plans of the Passaic class of monitors were completed, his first act was to send an entire set of tracings to Sweden. His countrymen lost no time in building a vessel in accordance with them, which having been gracefully named the John Ericsson, he purchased from our government, at an outlay of fifteen thousand dollars, a pair of fifteen-inch guns to be mounted in her turret. He also built at his own expense the boilers, engines, and propeller for a small gunboat for harbor defense, which he presented to the Swedish government; and, in a time when much suffering, particularly in his native province, was caused by famine, he sent a check for twenty thousand dollars for the relief of those in distress. His countrymen have always been not only grateful for these acts, but proud of his fame and his achievements, which have been rewarded by many titles and decorations from both his own and other governments.

During his later years he was exceedingly careful of his time, which he had devoted entirely to his work, declining to make new acquaintances, and refusing to see visitors except on rare occasions, and then according but brief interviews. This was not because of an unkindly disposition, for he was of a warm and sympathetic nature, but because he realized that the days became more precious as they passed away, and he could not spare a single moment from the labor upon which his heart was set.

Now, imperfect as this record is, it amply proves the originality, affluence, versatility, and energy that characterized the robust mind of Ericsson. From such an array of achievements it is not easy to select the most notable; still it is certain that the fame of the designer of the first steam fire engine, the first high speed locomotive, the first screw war ship, the first turreted ironclad, rests secure upon an eminence, a loftier than which no man as yet has reached.

It may be not unpleasing to some readers of the *Indicator* to learn that Captain Ericsson had always a kindly interest in the Stevens Institute of Technology. From the day of its opening to the day of his death, I do not recollect a single interview with him in which that interest was not manifested; not content with a general idea of leading features, he would ask keen and minute questions as to the nature of the work, the methods of instruction, the time devoted to this or to that, the changes made and the reasons for them—in short, no particular escaped his notice. His views in relation to technical education were clear and comprehensive. Naturally he was most thoroughly alive to the practical side of the subject, and he expressed great satisfaction at the increased facilities for work and experiment provided by President Morton in 1881. But, more than all, he was pleased to learn of the demand for Stevens graduates, and the success of Stevens alumni; because this furnished him tangible proof of the substantial soundness of the scope and scheme of our course, which had always met his hearty approval. —*The Stevens Indicator.*

AMERICAN OIL PIPE LINES.

AN elaborate article recently appeared in the New York *Times*, reciting the growth of the Standard Oil Company. We abstract the following:

The inside history of these pipe lines, could that be written from such knowledge as the Standard managers alone possess, would form one of the most interesting chapters to be found in American commerce and material development. It is a remarkable thing, even when viewed from the less advantageous ground of an outsider, who can see only the results without uncovering the springs of action.

It is estimated on competent authority that from $14,000,000 to $17,000,000 passed into the hands of the teamsters of the oil region for carrying oil from the point of production to localities where other transportation could be made available, before the introduction of the pipe line immensely reduced the cost of that carriage and destroyed a means of occupation for thousands of teamsters as effectually as the railroad drove the stage coach from the highways.

By whom the first suggestion of oil pipage came we may not certainly know, nor is it essential; but it is known that in 1861 an application was made to the Pennsylvania legislature for a charter under which a line of wooden pipes might be laid from certain oil wells to a place of storage and distribution. But the influence of the wagoners, nearly five thousand strong, was too great, and the charter was refused on the ground that the means of livelihood for the five thousand would be destroyed.

Efforts of an uncertain and unsatisfactory sort for the practical pipage of oil were made as early as 1862 and 1863, but a practical solution of the problem was not hit upon until 1865, when an improved method of joining the pipes made a success of what had been only a failure before. The story of Samuel Van Sycle's early experiments and trials may be briefly touched upon here.

He laid a pipe from his wells at Pithole to Miller farm, sinking it two feet under ground, and facing an ascent of over five hundred feet which his pumps would be compelled to overcome. He probably believed in the success of his experiment, else he would not have undertaken it, but there were few who shared in his anticipations. When the line was completed along the five miles of territory it was to cover, and the engines back of the pumps set in motion, incredulity was turned to wonder, as the oil went booming along its prescribed way, and was delivered in safety at the other end of the route.

When the owners and the drivers of the oil wagons saw this experiment a success, they endeavored to retard its operation as far as possible, and to discourage others from a like venture. They promptly went forth by night and tore up portions of the obnoxious line. It was repeatedly relaid, and as often broken, until at last watchmen were placed along its route by night. The power of the law was at last brought to bear, and as in all cases where personal interests are set up against a general improvement, the teamsters were beaten and driven from the field. The pipage of oil had come to remain.

As the experience and the needs of producers pointed out the way, other lines of a minor nature, and between various points, were built and set in successful operation. The pipe became the recognized method of carrying the oil to the refineries then established in the oil region, or to railroads by which it could be shipped to those at a distance.

With the lengthening of the pipes and the addition of the pressure for the forcing of oil to greater distances, men became more and more impressed with the possibilities of the new system of transportation, and those most enthusiastic began to believe that there was no point short of the seaboard to which it might not thus be sent.

A bold step was taken along this line of enterprise in 1875, when the charter of an organization called the Pennsylvania Transportation Company was obtained, with power to construct a pipe line from the oil region to the Atlantic. The only outcome of the venture for the time was the construction of various lines within the oil-producing territory, and although engineers of experience declared it might be done and some men of money were prepared to aid, the great iron conduit to the coast was not constructed.

Within two or three years, pipe after pipe crossed and paralleled each other in various directions, from the producing field to the place of storage and shipment at the railroad, while the various companies to which they belonged made war upon each other, cut rates, and at times did business at an actual loss. When the producer had run his oil into the storage tanks of some of these concerns he was not certain whether his certificate therefor was of value, yet affairs were such that he was compelled to have his oil run off through the pipes that were nearest him or allow it to pass back into the earth from which it came.

Competition and the lack of an effective system or a centralized power carried things along the usual course. The stronger crowded the weaker to the wall, and when the giant power that was already felt in oil affairs turned its attention toward the pipe lines, with a sagacious foresight as to what might be done by them and through them, and an unhesitating purpose to control at whatever cost of purchase, conciliation, or warfare, the end could not be far distant.

When the Standard had gained possession of the pipe lines already laid, as described above, or at least enough of them to give it a practical control of all, the often advanced idea of a line to the seaboard was again urged, and this time to those who had the means to build it and the faith needed for its undertaking. Improvements had meanwhile been made in pumping machinery, and when it was found that a pressure of 1,000 pounds to the square inch could be furnished, the engineers declared that it was sufficient, and the work was begun in 1880. Before long great gangs of delvers were stretching away in various directions, while mile after mile of pipes lengthened out toward the great commercial centers of the East, and West, and North.

One led as direct as the way would permit to the city of New York, from Olean, Cattaraugus County, N. Y., to Saddle River, N. J., a distance of nearly three hundred miles. Another, called the Pennsylvania line, stretched from Colgrove, McKean County, Penn., to Philadelphia, nearly two hundred and eighty miles. The Baltimore line began at Milway station, on the Pennsylvania line, and ran to the city of Baltimore, a distance of seventy miles. That into the great refineries at Cleveland begins at Hiliard's, Penn., and is one hundred miles in length. That to Pittsburg is sixty miles in length, and finds its beginning in Carbon Center, Butler County, Penn.; while that to Buffalo begins at Four Mile, Cattaraugus County, N. Y., and is seventy miles in length.

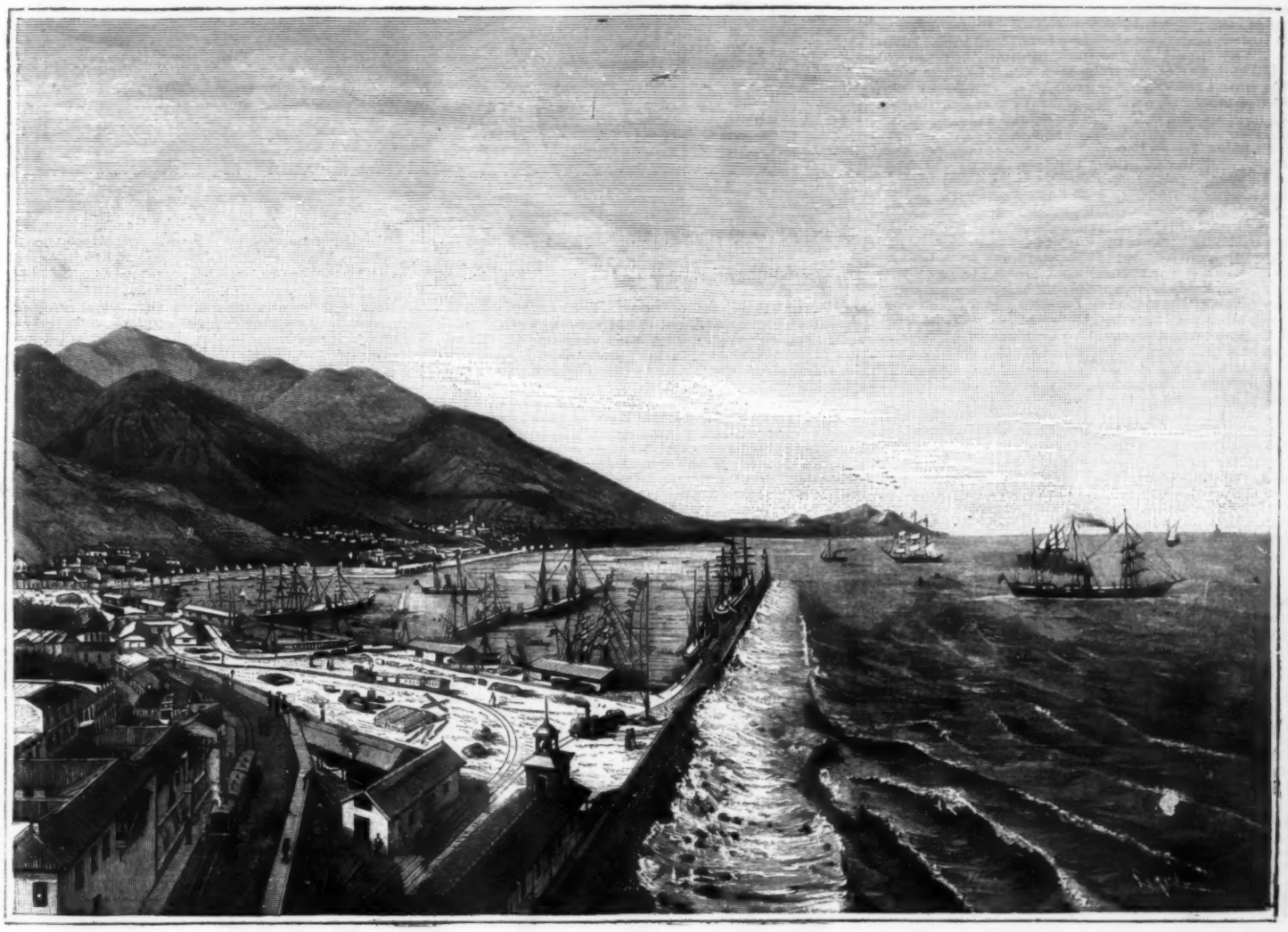
A main line was also built from Kane, McKean County, to Bear Creek, a distance of fifty miles, which served as a feeder to the oil, as oil could be pumped through it both ways. It would be impossible to describe the mass of smaller lines that cross the territory drained, in every direction, nor would a description made to-day be of exact value to-morrow, as new wells are constantly opened and old ones closed. Some idea of the immensity of this business may be gleaned from the fact that $6,000,000 does not represent the full value of the lines and tankage made valueless owing to the failure of the districts in which they are situated.

The name under which these consolidated lines are held was changed to the National Transit Company soon after the control was gained.

An opposition line was constructed after the opening of the Bradford field from that point to the Reading railroad at Williamsport. But it was not long left out of the grasp of the hands grown strong to hold so much, and willing to hold all. In the summer of 1883 word went forth that the Tidewater Pipe Line, the name under which the independent artery of oil transportation was laid, had fallen a victim to the Standard and become one more of the monopoly spoils. This result had been foreshadowed for some time, but those who had depended upon it for the carriage of their oil hoped against experience and the inevitable, and thought that it might be spared. But the papers were signed near the middle of August, and the Standard found itself in the control of the transportation of crude petroleum and the trade in refined oil.

The Standard has recently built a pipe line from Lima, in the Ohio oil field, to Chicago, thus giving it one more link in the great chain. Its length is a little over two hundred miles.

Ohio and Pennsylvania have in the past made valiant although, so far, unsuccessful attempts to place them under control of the law. The effort to make the standard line to Cleveland a common carrier, made in the Ohio legislature several years ago, failed only because the Standard made desperate efforts to defeat it, and employed means that smirched those by whom that defeat was directly accomplished. Pennsylvania made an attempt somewhat similar in the Billingsley bill, presented at a late session of the legislature. It passed the lower house, but failed in the upper. John D. Archbald, now of New York, but a Pennsylvanian until recently, was present, and as long experience in the methods of Harrisburg had given him a knowledge of the needs of the situation, the measure was defeated on a final passage.



LA GUAYRA, VENEZUELA.

PROPOSED NEW TUNNEL AND GRAVITY RAILWAY BETWEEN NEW YORK AND BROOKLYN.

THE Henning Gravity Tunnel Company proposes to build a tunnel from Broome Street, New York, to a point near Broadway, Brooklyn. There is to be a double track railroad in the tunnel, which is to be operated by the East River Railroad Company. The latter company was incorporated with a capital of $100,000.

The plan is to construct a tunnel on an incline from each end, the descent to be about 15 degrees. When a car is started at either end gravity will carry it on the down grade, and when it reaches the lowest point it is expected that it will have enough momentum to carry it part of the way up the incline, to a point where the car will grip a cable, by which it will be hauled to the top.

The tunnel is to be between 2,000 and 3,000 feet long, and it is calculated that the trip through it can be made in a minute. The plan looks practical and economical. Gravity railways are a success, are safe, and pleasant to ride upon.

LA GUAYRA, VENEZUELA.

THIS place is situated at the base of a chain of high mountains, which form an imposing wall directly in the rear of the city. It was founded by the Spaniards in 1588; was twice besieged without success by the English, in 1739 and 1742. In 1812 the city was ruined by a terrible earthquake, but it has been rebuilt, and is now one of the most important commercial centers of the country. Its population is 16,000. It exports immense quantities of coffee, cocoa, indigo, hides, etc., the largest portion of which are purchased by citizens of the United States.

ON ACTIVE OXYGEN IN VITAL PHENOMENA.

AN ABSTRACT OF ORIGINAL RESEARCH.

By BENJAMIN WARD RICHARDSON, M.D.

IN previous papers I have treated on the actions of heat and cold on oxygen, and on vital and devitalizing oxygens. In the present paper I am about to refer to the modification of oxygen called ozone, and to the influence of ozone on vital phenomena.

When oxygen gas is exposed to various electrical states, it assumes new characters. It may be made almost as irrespirable as chlorine; it may be reduced to the nearly negative condition of nitrous oxide. In the common air it exists in a neutral condition, as a general rule; but the rule has its exceptions, and upon these exceptions much depends, having relation to disease. There are times when active oxygen is present in the air, "the ozone periods" of Moffat. There are times when the oxygen is negative.

I am not certain that the use of the terms *active*, *neutral*, and *negative*, as applied to oxygen under various conditions, are really correct or good terms; because, in truth, heat also makes oxygen negative, neutral, or active, as electricity does. Oxygen reduced to very low temperature is, as we have already seen, negative in reference to the support of life; oxygen at ordinary temperature sustains life best; and oxygen at elevated temperatures causes an over-active animal combustion. But custom has willed it, and I suppose custom must have its way, that the terms active, neutral, and negative shall be made to apply to oxygen as existing under different electrical states.

That oxygen should be influenced by electricity as well as by heat is not difficult to understand. When electrical discharge occurs in oxygen, it puts the molecules of the gas into active motion, and their affinity for other bodies with which they are brought into collison is increased. As, by the lightning flash, great waves of the atmospheric sea are put into motion, and thunder is the result, so in the more minute divisions of that atmospheric sea, in the molecular divisions, whenever there is electrical discharge, great waves are put into active motion, the effect of which is exhibited in the more active combinations that occur between oxygen and oxidizable matter.

To prove that heat and electricity are similar, in respect to their action, to oxygen, it may be stated that oxygen, heated to a temperature of 480° Fahr., ceases to be influenced by electrical discharges. To use the

term common in experiment, oxygen cannot then be ozonized; this simply means that the motion imparted by the heat is itself so great that the effect of the electrical discharge becomes unimportant. In the opposite scale, oxygen reduced to a very low temperature is not more inert because it is present as negative oxygen; which means that, when inertia and condensation are produced by extreme abstraction of heat, the reduction of the electrical motion is not of moment.

It is well to bear in mind these analogies of action between the forces of heat and electricity; but with this remembrance it is also well to hold in distinct recollection the exact influence of electricity on oxygen, both in its simple state and as diluted in atmospheric air. To this I will now proceed.

Active oxygen or ozone may be produced by several processes: (*a*) By the manner in which we make oxygen, or rather evolve it, from bodies with which it had before been in combination. (*b*) By the slow decomposition of water, whereby the oxygen is set free. (*c*) By the exposure of phosphorus to air in the presence of water. (*d*) By electrical discharge.

For practical purposes, the production of ozone is best carried out by electrical discharge. In the experiments about to be related, a large frictional machine was employed when the quantity of ozone required was small; an apparatus invented by the late Sir William Siemens when the quantity required was large.

In the Siemens apparatus, the electrical discharge is obtained by means of a large induction coil, worked by three cells of a Grove's battery. A spark of 2 inches is thus obtained, and is discharged in an ozone producer, which consists of two glass tubes, an outer one having a bore of 3 inches, and an inner one a bore of 2 inches; the inner tube is covered on its outer surface with tinfoil, and the outer tube is covered in the same way. When in action, one pole leading from the induction coil is attached, by means of a platinum wire, to the tinfoil on the outer surface of the inner tube of the ozonometer, and the other pole is attached to the tinfoil on the outer surface of the external tube. When electrical discharges are now made, air, or oxygen, on being driven between the two tubes, becomes ozonized, and the ozonized product can be collected from an escape tube. The air can either be driven through with bellows or drawn through with an aspirator.

By means of this apparatus, ozone can be applied either by being collected in suitable vessels, or by being used in a current through a chamber so arranged as to receive a stream of ozonized air, entering by two openings at a side near the bottom and escaping at the top by a tube, where it may be collected for analysis. Or a chamber may be adapted so as to receive from time to time certain measured quantities of ozone, by means of a graduated cylinder filled with ozonized air, from which, with a well-fitting piston, the ozone, by the depression of the piston, may be driven into the chamber as required.

One other little matter of fact in respect to the carrying on of experiments should be carefully noted. It is useless to attempt to carry the ozonized air through India rubber tubing of any kind, or through gutta percha, for both these forms of tubing are destroyed by ozone, as they would be by heat. The ozone should therefore be passed through glass tubes, and the connections, which ought to be as short as possible, made by quills cemented in with sealing wax varnish, a contrivance by the late Dr. T. Wood.

SUMMARY OF PHYSIOLOGICAL EFFECTS.

In experimenting with ozone, it is necessary for the operator to proceed with caution, so as to protect himself from the danger of long inhalation of ozonized air. When ozone is being produced in quantity, it is next to impossible to prevent diffusion of it through the apartment, and in a very short time its effects are manifested on the body. The inhalation of ozonized air, even when I can scarcely detect its presence by the odor, produces in me, after a time, intense headache and pulsation. If I breathe it a few times from the tube, it creates irritation of the lining membrane of the nasal cavity, and acute injection and soreness of the throat.

In considering the action of ozone on vitality, I commenced with the simplest experimental position, viz., the influence of electric discharges on pure oxygen. Up to the time when these researches were made (1865), no systematic inquiry had been carried out on the subject, and I have not myself resumed the inquiry; but the facts then elicited have been sustained by later observers, and are, as it seems to me, deserving of record as the completion of the series of my original observations upon the part played by oxygen in the processes of life.

On pure oxygen at a temperature of 55°-60° Fahr., electrical discharges, creating ozone in quantities just sufficient to be appreciated by the sense of smell, give such motion to the oxygen as enables it to support life, after the same manner as an elevation of temperature. I took two large mice, and placed each one in a chamber containing oxygen at 55°. The chambers were of the same size, and the oxygen was from one source. When the animals were in their respective chambers, the chamber containing one of them was so placed that sparks from a pointed rod of a frictional electric machine could be discharged into it. The chamber containing the second animal was placed in the same temperature, but the oxygen in it was not electrified. At the end of two hours, the animal in the simple oxygen was comatose and was breathing very slowly, while the other animal, in the ozonized oxygen, was moving about and breathing rapidly but freely. Two hours later, the animal in simple oxygen was dead, and half an hour later was rigid from rigor mortis. At this time the animal in the chamber into which the sparks were passing was sleepy but living, and so it continued sleeping for an hour longer, when, on removal from the jar, it speedily recovered, as if from the effect of an anæsthetic.

In another experiment, a mouse was placed in an oxygen chamber at 55° Fahr., in communication with an electrical machine, so that the gas could be ozonized. At the same time, a similar animal of the same weight was placed in an oxygen chamber of equal size, and was removed simply to a temperature of 75° Fahr. The animal in the ozonized air lived on for nine hours; the animal merely exposed to a temperature of 75° Fahr. was then also alive. The animals, on being removed from their chambers and brought into the air, were in a deep sleep; they both readily recovered after removal into the ordinary atmosphere.

We may thus consider that heat and electricity exert an analogous action upon oxygen; but, in watching the last-named experiment, I was wonderfully struck with the power exerted upon the oxygen by the electrical spark. I held as it were the life of the animal in my hands, and by the rotations of the electrical wheel could quicken or reduce the respirations at pleasure. If I surcharged the gas, by discharging the sparks rapidly, the animal began to breathe with increasing haste; if I held back the motion for a long time, then the animal fell into a low, comatose state, and would soon have died asleep, had not motion been imparted again to the molecules of oxygen.

I performed another experiment by placing two animals (mice) of the same weight in chambers of equal size. One chamber was charged with oxygen in the form of absolute ozone; the other chamber was charged with simple neutral oxygen, and both animals were placed in a temperature of 60° Fahr. The animal in the ozone commenced at once to breathe very quickly, became fast asleep in an hour and twenty minutes, and died asleep in two hours and forty minutes. The animal in simple oxygen also became sleepy in an hour and twenty minutes, but continued to live, asleep, for four hours and forty-two minutes.

In this experiment we witness the effect of ozone as applied to the animal at once. The warmth in this experiment was sustained throughout uniformly at 60° Fahr., and the animal that was subjected to the motion produced by the warmth alone lived longest; but the animal that was subjected to the motion added by electricity died more speedily.

When the temperature of the oxygen was raised to 70° Fahr., and when at that temperature it was ozonized, it became rapidly fatal as an atmosphere to all animals exposed to it. A rat and a guinea pig put into the chamber at the same time, but separated from each other by a partition, were affected with similar symptoms from this atmosphere. The first and main symptom was quickened breathing, which continued throughout, and was due, as the post mortem showed, to extreme congestion of the lungs rapidly induced. Death occurred more quickly in the carnivorous than in the herbivorous animal, the first dying within the hour, the second in an hour and a quarter.

In the post-mortem examination of animals killed by this inhalation of ozone, the lungs were found intensely congested and the blood firmly coagulated in all the blood vessels. No other organs were affected; pulmonary congestion and the hyper-plasticity of the blood caused the death.

One fact stood out strikingly in the whole of this research, a fact of great moment, both physiologically and as a matter of natural history, namely, that animals of the carnivorous order are much more quickly brought under the influence of ozone than are herbivorous animals. It is as if those animals which live direct from the vegetable world, and which prepare food for the carnivora, either do not ozodize so rapidly as the carnivora, or use up more oxygen without injury to themselves.

If this view should be confirmed by further observation, it may throw a flood of light on the cause of the difference of diseases of the same kind in the different classes of the animal world, carnivorous and herbivorous; why variola, for instance, in man is vaccinia in the bovine species, and why some diseases are only communicable among special classes of animals.

The hypothesis here stated has about it nothing but what is reasonable. For as disease of any kind is never anything more than the phenomena of perverted molecular motion, and as in different classes of animals there is a special order of oxidation for the generation of motion, so the phenomena of disease must differ according to class.

In the essay on vitalizing and devitalizing oxygens, I pointed out how easy it was to explain why, when the air is stagnant and close, it makes the body and mind depressed; and why, again, when the air is electrified by a thunderstorm, it is revitalized and made once more active for the support of life. In a word, I showed that but for the natural electrical battery constructed of water, air, and earth, the atmosphere itself would be useless for the purposes of life, and all living things would die.

In these researches on electric or active oxygen, we see the opposite of this picture. In an air surcharged with electric oxygen, and with the temperature high, there is danger from the over-action that is produced; and no doubt a certain amount of disease is produced in this way.

Fortunately, in the balance of forces there are two protective influences at work. In the first place, the great ozonized currents of air, carried in the equatorial regions to an immense height, are turned over to the poles, and in that grand circuit are rendered negative before they return in the line of the earth to the temperate and torrid zones. In the second place, ozone attacks and decomposes dead rather than living matter. Living matter is already charged with it, dead matter is ready to receive it, and therefore uses it up. Thus, to a certain extent, our very refuse, our organic excreted offensive refuse, is rendered of vital service by devouring and utilizing for new life our otherwise vital destroyer.

In the laboratory we are able to feel and prove this exposition. When the air is rendered painfully active from the presence of ozone, a spray of ammonia water is sufficient to seize the active oxygen, decompose it, neutralize it. But ammonia is the grand product of so-called dead organic things; *it is the atmosphere of decomposition;* and that which is made to go on, on the minor scale, in the laboratory of the chemist when ozone meets ammonia, is always going on in the laboratory of nature, in which life and death are one continuous event.—*The Asclepiad.*

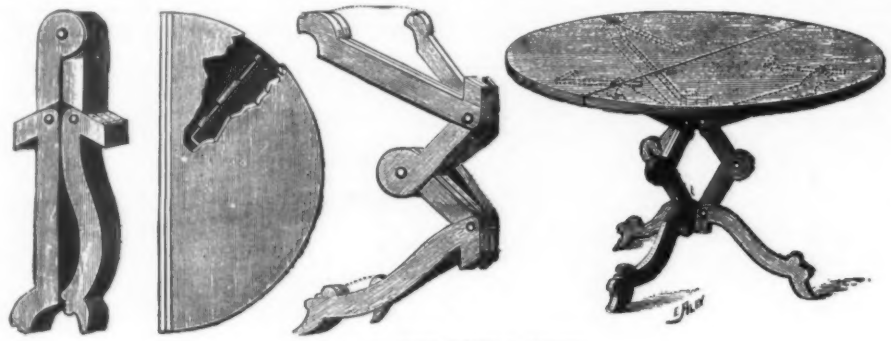


FIG. 1.—FOLDING TABLE.

JOINTED FOLDING FURNITURE.

THE carriage of furniture into and out of houses on moving always presents numerous difficulties. Sofas, armchairs, and ordinary tables cannot be taken apart or reduced in bulk. In order to pass them through doorways which are usually narrow, it is necessary to make an effort and turn them in all directions. They are almost always injured by the blows that they receive.

Mr. Zeffro Massa has devised a system of folding furniture of almost every variety. As a sample of these we herewith figue a table and a settee.

The table consists of two parts, the top and the support. The top, which is circular in shape, is separated across its diameter into two equal parts, connected by hinges. The support consists of three jointed legs. These fold up against each other and form a bundle. How the table is mounted will be readily understood.

The settee consists of small iron bars coupled in the form of an X. When it is reduced, it takes up hardly any space.

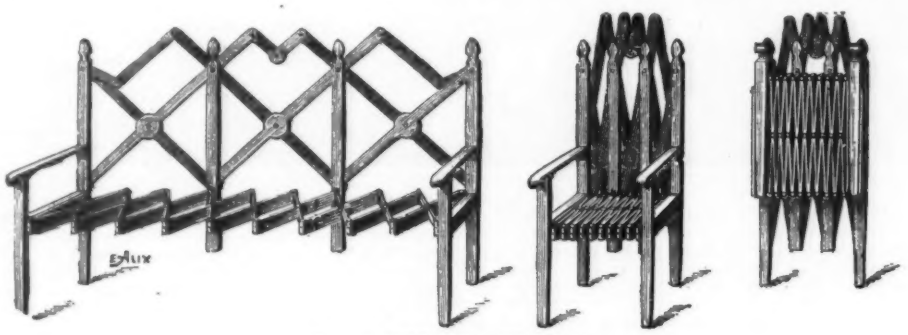


FIG. 2.—FOLDING SETTEE.

It is first converted into an armchair, in which one person may sit; then, in order to form a settee, it suffices to pull apart the end bars. The X shaped bars then open out and extend the seat, upon which several persons may sit. The figures well show these various transformations.—*Les Inventions Nouvelles.*

DOMES AND TOWERS.*

By J. H. MCNAMARA.

THERE are no features of architecture so pleasing as domes and towers. However beautiful may be the porticoed entrance, however bold the projected pavilions, or however varied or extensive the facade, the eye will single out the dome or tower, and with instinctive pleasure follow it up to the summit.

Though domes crown the grandest buildings in the world, I must confess that I never look on a dome with the same degree of satisfaction that I feel when looking on a tower.

* Paper read by Architect J. H. McNamara, of St. Louis, before the convention of the American Institute of Architects, held at Cincinnati, November 21, 1889.—*From the Building Budget.*

No matter how much I may assume that all the necessary consideration has been bestowed on the principles governing domical construction, its theory of equilibrium and lines of gravity, yet am I unaccountably possessed of the idea that those gracefully swelling outlines cover a world of ingenious expedients to hide the actual construction of the towering mass, carrying on its interior so much sham work of lath and plaster; taking the form of antæ and entablatures, heavy groupings of pedestaled victories and statued niches.

Of all the great domes that have been built in the past six centuries, not one can compare with the first aerial dome, that of Santa Maria del Fiore, at Florence, built in the twelfth century, by Brunelleschi. In this alone do the outer and inner domes sweep upward in parallel lines, springing from the same arched base, and are the actual supports for the beautiful lantern surmounting them. The nearest approach to the honest construction of Santa Maria is St. Peter's at Rome, that was modeled after it in the fifteenth century, by Michael Angelo. Although its two domes do not run quite parallel, they will come under the weight of the lantern.

Both St. Paul's, at London, built in the sixteenth century, by Sir Christopher Wren, and the Pantheon at Paris, built in the seventeenth century, by Antoine, have each three domes, springing from the same perpendicular base, but each sailing away in a direction for itself, looking as if each one was crowded down by the one above it. Both domes are outwardly beautiful and interiorly false—from the fact that one of the three must be useless. Particularly does St. Paul's possess both of these features. And the St. Paul's of Paris, the Dome des Invalides, built in the sixteenth century by Mansard, the originator of the "Mansard roof," is of the same class.

President Hunt: I think the architect of the Pantheon was Soufflout and the builder was Rondelet. And it is one of the most wonderful domes that has ever been erected. It consists, really, of three domes, one inside of the other. The second dome carries a painting, which you see through the eye of the first or inner dome from the floor of the church. Then there is a third or outer dome. There are staircases proceeding from the four corners of the second dome—which really stands on four legs, so to speak—with a very aerial appearance, and are the prettiest specimen of stone cutting that I ever saw. They run up in the area between the inner and second domes, reaching from the base of the second dome to the eye of the inner dome. In order to lighten the enormous weight of the outer dome, a system of niches have been scooped out on the inside of it. Furthermore, originally all the three domes were supported on a cluster of columns at the crossing in the church. These columns were put up with almost perceptible joints, they being concave, so that the pressure was brought on the outer edge of the column. But in the time of Louis Philippe there were appearances of settlement, and these clusters were replaced by piers, which still exist.

BRICKMAKING MACHINERY.

By M. POWIS BALE, M. Inst. M.E., A.M. Inst. C.E.

INTERESTING though the ancient history of bricks and brickmaking may be, it is not our intention to dwell on it here, but rather devote ourselves as far as may be to the consideration of the modern machinery which has been invented to save labor, to economize time, and improve, if possible, the quality of the output.

This being an age of universal and keen competition in all classes of manufacture, hand labor has of necessity been largely superseded by mechanical means, and brickmaking has been no exception to the rule. In some cases, however, the introduction of brickmaking machinery has not proved a commercial success, owing to its principle of working or construction being ill-suited to the nature of the clay or mixture of clay and other materials it has had to operate on.

Clay may be broadly stated to be a mixture of the two earths, alumina and silica, combined with water. As to the origin of fine clay, Fownes says: "Silicates of alumina enter into the composition of a number of crystallized minerals, among which feldspar occupies, by reason of its abundant occurrence, a prominent place. Granite, porphyry, trachyte, and other ancient unstratified rocks consist, in great part, of this mineral, which, under peculiar circumstances, by no means well understood, suffers complete decomposition, being converted into a soft, friable mass of earthy matter or clay."

Gmelin says that the clay is usually mixed to a greater or less extent with carbonate of lime, magnesia, and protoxide of iron, which cause it to effervesce with acids; it also contains manganese, finely divided quartz, feldspar, mica, organic matter, etc., all of which modify its properties and applications to a considerable extent.

The presence of potash, lime, sesquioxide of lime, etc., renders it more fusible.

Firebricks are made from a compound of silica and alumina, and the clay owes its refractory qualities to the absence of lime, magnesia, potash, and metallic oxides, which act as fluxes.

Common clay or brick earth may be roughly divided into five chief classes of red, yellow, brown, blue, and black; it is found, to a greater or less extent, in many parts of the world, but differs very considerably in its chemical constituents, and, therefore, in its color and nature, being rocky, leathery, loamy, stiff, dry, stony, rich, poor, etc.

In Great Britain some hundreds of different clays are to be found more or less suitable for making bricks; but many of these vary largely in their composition and quality, and therefore require varied treatment in their manufacture, and it is folly, therefore, to expect one kind of treatment or class of machine will act equally well on all classes of clay.

It need hardly be said that in introducing machinery to secure success, great care should be exercised in its selection; in point of fact, the clay should be tried, and bricks made on several machines, and not only should the bricks be moulded, but *burnt*, as a clay or machine may appear to work satisfactorily, and yet

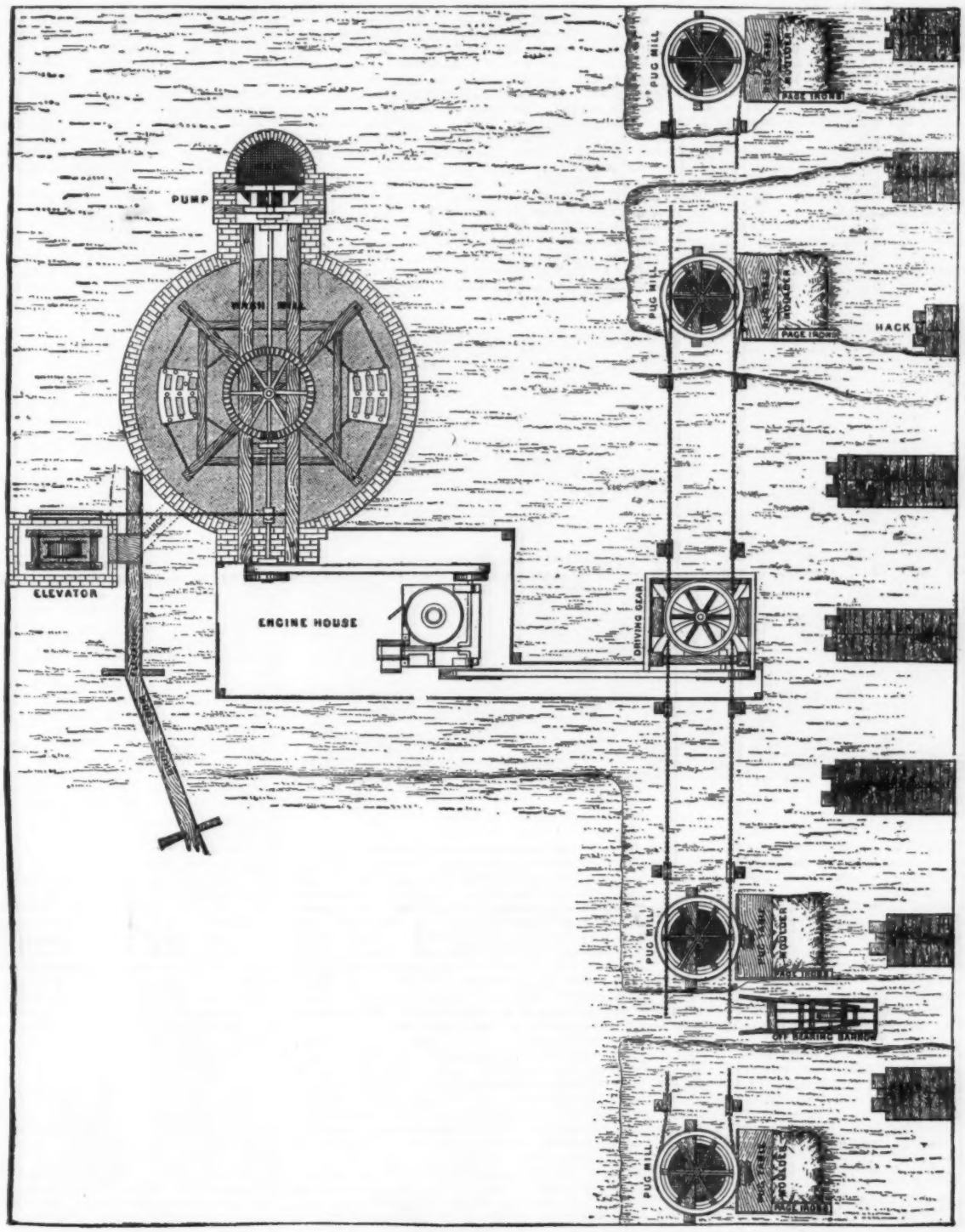


FIG. 1.

a large number of wasters may be turned out. In this case it may be safely concluded that something is wrong either with the clay or its manipulation, the machine or the burning.

It is never safe to trust to the casual examination of the clay for the manufacture of bricks, tiles, etc., as we have seen on several occasions what appeared to be almost pure plastic clay, and should theoretically have made excellent bricks, burst to pieces in the drying.

The clays found in different parts of the country often require entirely different treatment; for instance, light, sandy, or loamy clays require a flux to bind them together, while strong clays may require an admixture of sand or loam, and others very little preparation before being made into bricks.

Again, the clay may be too rich, too wet, or too stony, or, as often is the case in the South of England and Ireland, contain small limestones, etc., which, when the brick is burnt, becomes lime, and when wetted the lime is slaked and bursts the brick.

Other clays contain pebbles, metallic oxides, magnesia, pyrites, etc., and often require considerable manipulation by means of crushing, washing, etc., to render them fit to be made into bricks.

In some cases, where clays contain much lime, alkalies, salts, etc., good bricks cannot be made from them under the ordinary treatment, as they warp or burst in the burning; but we hear success has been recently achieved even with this refractory material.

Again, clays which require a flux of breeze, chalk, etc., cannot be successfully moulded except under pressure, the ordinary machines using wire for cutting the bricks being quite unsuitable, unless the bricks be afterward pressed, owing to the rough surface left on the face of the clay through the wires coming in contact with the particles of breeze, etc.

The question of clays and their constituents is largely a matter for the chemist, and a complete analysis would in many cases be of much service; but looking at the question in a practical point of view, we cannot do better than reiterate our advice to those contemplating brickmaking, viz., to have the clay thoroughly tested and see that the process and machines adopted are exactly suited to the nature of it.

By incurring a small first outlay in this connection, much loss and disappointment may often be saved.

There is no doubt, however, that very great improvements have taken place of late years, both in the methods of manufacture and the machinery employed in the semi-dry or semi-plastic processes.

Many clays have been dealt with semi-dry that were quite unsuited in their nature for treatment by this process; consequently when the bricks were burnt they were more or less porous, and light cracks and flaws appeared. Consequently when the bricks were laid and subjected to atmospheric influence and wet, perhaps followed by frost, they commenced to disintegrate, and their surfaces scaled off.

Speaking broadly, I take it the clays most suitable for the semi-plastic processes are those of a bituminous or shaly, etc., nature, and which vitrify to a certain extent when fired. Even suitable clays often require careful handling, and, if very rich, to make a sound brick an admixture of fine ground ballast, sand, or other material, in a proportion according to the nature of the clay, is necessary. These admixtures will often prevent excessive shrinking and warping of tough, stiff clays, and the ballast opens the pores of the clay to a certain extent, and permits the escape of the water contained in it. The object of the semi-plastic process is, of course, to lessen the cost of production by transferring the bricks directly from the moulding machine to the kiln without the intermediate process of drying in the air or in heated sheds, as is the case with the ordinary plastic process. Some clays will stand this treatment satisfactorily, and make first-rate bricks, but many will not. Some are of too dense a nature, and the steam formed by the water in them during the burning cannot readily evaporate; consequently, it flaws, cracks, and in some cases bursts the brick altogether. Again, weak and friable clays are unsuited for the semi-plastic process, but are sometimes used, and when turned out from the moulding machine possess a clean and dense appearance, but after burning they become open and weak, the particles of clay not being sufficiently bound together. Given, however, a suitable clay, and there is no doubt that good bricks may be made by the semi-plastic process, and in countries where the cost of labor is high, at a considerably less cost than with the plastic process. The clays in this country that are, however, quite suitable for semi-plastic working are comparatively limited, and the employment of this process on clays better suited to the plastic process (the result being unsatisfactory) has tended in some instances to bring the semi-plastic process into more or less disrepute. Speaking generally, the plastic process (when bricks are made and dried before passing into the kiln) may be fairly pronounced the safest in its results, and less skillful management is necessary. The matter under discussion, therefore, resolves itself into a question as to the nature and suitability of the clay to decide which process of manufacture is the best to be pursued. It may be added that, with the dry process, it is claimed that brickmaking may readily be carried on all the year round.

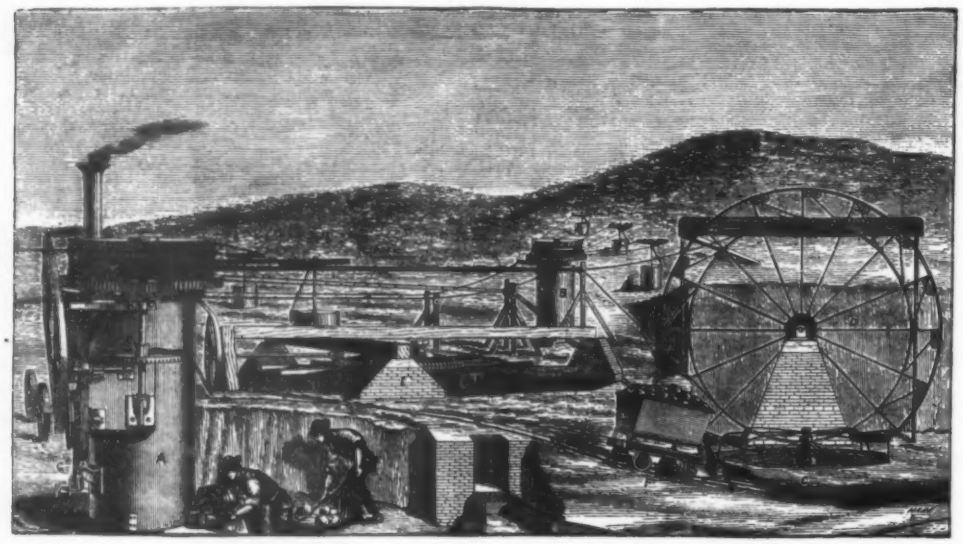


FIG. 2.

These remarks will, of course, apply equally well to the manufacture of hollow, coping, arch, feather-edged, capping, and other special bricks, tiles, pipes, etc., as it does to ordinary building bricks.

It may not be out of place here to observe that a thoroughly good brick should combine as far as possible soundness and hardness with uniformity in shape and size. It should have a good skin to render it impervious to the weather, and be capable of standing considerable compressive strain.

Stock bricks, if sound and well burnt, should give out a clear, sharp ring when knocked together; some kinds of facing bricks, however, although perfectly sound, will not ring.

Bricks are sometimes found streaky in sections when broken, and mottled on the outside; this will often arise from insufficient pugging and preparation of the clay, a point that cannot be too much insisted on in the manufacture of first-class bricks, as layers of clay different in nature are often found in the same field, and unless these be thoroughly amalgamated, the result cannot be satisfactory.

BRICKMAKING PROCESSES.

Brickmaking, although subjected to many modifications rendered necessary by the nature of the clay or the kind of brick required, may be divided into two great processes: (1) the plastic; (2) the semi-plastic or semi-dry.

For some years much heated discussion as to the merits and demerits of these two systems has taken place; but it is not our intention on the present occasion to deal with the matter in a partisan spirit, but rather to point out briefly some of the advantages and disadvantages of each.

We have seen good bricks made under both processes; but there is no doubt that many clays can be safely made into bricks under the plastic process that would be more or less failures if worked semi-dry. As a sign of the "survival of the fittest," what was formerly termed the dry process has now given place to the semi-dry or semi-plastic.

The chief reason for the discontinuance of the dry process was the difficulty—although enormous pressure was used—of properly cementing together the more or less dry particles so as to form a sound and dense brick when burnt.

The duty of brickmaking machinery, especially pressure moulding machines, is generally very severe; consequently it is necessary, to secure success, that it should be of massive construction to withstand the various strains put upon it. It should be soundly made, and the various working parts adjustable for wear as far as possible. Either from excess of competition, or other causes, this has not always been borne in mind, and the result has been in some cases machinery of far too flimsy a construction for the work it has to do. It may not be out of place here to caution users against being tempted to purchase very low priced machinery, as a really well designed and constructed machine cannot be sold except at a price that will give a fair return for the talent and outlay of the manufacturer. So-called cheap machinery is really dear at any price, as it usually means a lessened output of worse quality, combined with a largely increased bill for repairs.

NOTES ON PLANNING A BRICKWORKS.

The careful planning of brickworks has much to do with its commercial success, although we are afraid that sufficient attention is not always given to this important point, the result being a considerable loss through increase of labor in handling and manipulating the materials. We are aware that all kinds and sizes of sites have to do duty as brickworks, and our remarks thereon may not in all cases apply; they must therefore be considered as general, and not arbitrary. In selecting a site, the chief point to be considered is the facility as to land or water carriage. Unless these are good, and the produce can be cheaply and readily conveyed to the market, the works can never be a great success, unless it be in the case of a large contract where clay can be found near at hand. Water conveyance is usually by far the most economical, and a site having this should generally be selected in preference to one having road or rail, unless the market should be within very easy carting distance. If a site is to be had with good clay on or near the surface, so much the better, as this will lessen considerably the cost of production. Having secured a site, then comes the question of laying it out to the best advantage. This must depend largely on the nature and size of the field. No arbitrary rules can, therefore, be laid down. All manufacturing works should be designed as far as may be on what may be termed the progressive system—that is, the rough material to pass in at one end of the works, through the various machines, and out at the other as manufactured articles. This principle can in many cases be applied to brickworks.

For the sake of illustration we will in the first place imagine a 20 acre field to make say ten millions of London stocks, grizzles, and place bricks per annum. In most cases the machinery, etc., would be best placed somewhere near the center of the field, and after the backs are made the clay brought by suitable tram lines from the far end of the field directly to the wash and chalk mills; after being washed it would pass into the back for weathering; then, by means of elevators, to the pug mills, which should be placed alongside, afterward to the moulding shed, then to the stacks or drying sheds, and finally to the kilns or clamps. After the bricks are moulded, it is important that they should be stacked so as to allow of as much air as possible to pass through them, but they should be protected from rain, sun, and strong winds. The stacks should be arranged with a slight fall, if possible, be leveled and drained, and covered with fine ashes. Many drying sheds are now steam heated, but about this we may have something to say elsewhere, and also of the kilns.

We illustrate herewith (Fig. 1) a neat arrangement of chain, etc., driving gear from the designs of Messrs. Bastin & Lawson, 49 Finsbury Pavement, London, E. C. It is especially designed for hand moulding pursued in the London district, or where it is necessary to wash the clay. As will be seen from the plan, the windlass, driving gear, and chalk mill are each driven by belt direct from the engine, and the power is conveyed to the various pug mills from the driving gear by means of chains, supported at intervals by grooved pulleys. A well is also shown from which water is raised for the wash mill by means of a vertical barrel pump mounted in a frame, and driven by toothed gearing from the wash mill shaft, the clay elevator being driven by chain from the same shaft. The pug mills are shown placed in a line, but could be arranged in any other desired position, and the wash mill and elevator could be worked from the driving gear if preferred.

The selection of the engine and boiler and machinery has now to be considered, and is, without doubt, a matter of very great importance in securing successful working. With reference to the best kind of engine and boiler for the work, much will depend on (1) the quality of the feed water (2) the quality and cost of the fuel.

Should the feed water be bad, a simple form of boiler readily cleaned—such as a Cornish or a Lancashire—should be chosen, and these will be found especially convenient in the London fields, where ashes are used to mix with the clay, as much of the waste can thus be burned. Where the feed water and fuel are good, a locomotive boiler will be found economical. In brickworks the engine management is not always very skilled, and where fuel is cheap a plain high pressure engine may often be used with advantage, the liability to break down being lessened. Where the management is good and fuel expensive, a compound condensing engine can be recommended.

The engine and boiler being secured, the question arises as to the way of transmitting the power. In the London fields, where the works are generally of a temporary character, and the plant somewhat scattered, chain gear is usually employed, and it possesses the advantages of a comparatively low first cost and adaptability, it being capable of being readily lengthened or shortened as may be required. In the Midlands and elsewhere, where the works are more permanent and the machines not often moved, shafting is considerably used, and possesses some advantages over chain gear; but if the machines are much scattered or at different levels, it becomes very costly, to say nothing of the large amount of power used in turning it—about one H. P. for every ton weight of shafting. We have recently inspected a new kind of wire rope gearing, which has some interesting features, and possesses the advantages of lightness with strength. It consists briefly of an ordinary steel wire rope, through which are inserted at intervals a series of steel pins, fastened in a very ingenious manner, and rendering it almost impossible to pull them out. These pins gear into suitable wheels after the fashion of a pitch chain, and for long distances especially this chain should prove very serviceable. If chain gearing be employed, the windlass should be fixed near the engine, and the chain guided and supported to the various machines, if at any distance, by a series of grooved rollers mounted on posts. For those desiring further information in this connection, the author can recommend the perusal of a very interesting paper on "Brickmaking," by H. Ward, *Proceedings* Inst. Civil Engineers, April, 1886.

If line shafting be used, steel is to be recommended in preference to iron, it being stiffer in work, and there is less strain on the bearings through the shaft springing. Steel can also be used of somewhat less diameter than wrought iron for the same duty, and, if sound, will run with less friction. The difference in first cost between steel and wrought iron is small. Line shafting is subjected to considerable torsional and bending strains, at the same time its duty is intermittent, and has to submit to the severe, suddenly applied loads of starting fresh machines. It should, therefore, have a fair margin of safety. A general rule for finding the diameter of a shaft suitable for transmitting a given nominal H. P. is as follows: Multiply the horse power by 85 for steel, or 170 for wrought iron, and divide the product by the number of revolutions per minute; the cube root of the quotient will be the diameter of the shaft in inches. If shafting is used in a very long line, it becomes at the extreme end, especially if much pow-

er be taken off, very much inclined to twist; provision must, therefore, in those cases, be made to overcome the torsion. In arranging shafting, the first length which receives the power from the prime mover should be of greater diameter than the remainder, and the bearings placed closer together. A bearing should be placed on each side of the pulley or toothed wheel receiving the power from the motor, or any pulleys transmitting large power. Brickmaking machinery, as a rule, runs at a slow speed; consequently the main line shafting must run slowly. A very convenient plan, in many cases, is to transmit the power directly from the engine to the main shaft through the medium of toothed gearing.

In the Midlands and some parts of the north of England, substantial buildings are often erected for brickworks, and their arrangements and plans differ essentially from those near London, owing to the different nature of the clay and the methods of working it. In many of these the process pursued is to hoist the clay up and pass it through several pairs of crushing rollers, and in cases where the clay is over-rich, sand or burnt ballast is added in suitable proportions. After going through the rolls the clay passes into a mixing pan, and from thence into a pug mill, and onward through a wire-cutting or pressure-moulding machine, as the nature of the clay dictates. There are, of course, many modifications of these operations made in various parts of the country adapted to the nature of the clay, some of which will require a great deal of preparation, and others very little. For instance, should the clay contain large stones only, they may be generally got rid of by means of a screen fitted to the brickmaking machine; but clay containing a large number of small stones must either be washed or passed through either powerful crushing rolls or edge runners.

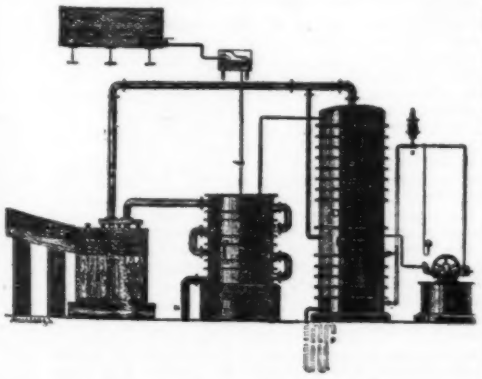
Our illustration, Fig. 2, represents some of the various gears used in the London brickfields with a new form of elevator, designed by Mr. W. Eddington, London, to take the place of the ordinary vertical chain or belt elevator. Fig. 2 represents a chain gear windlass mounted on a wrought iron pug mill, and arranged with spur gearing on the slow motion. In practice, however, it will usually be found much more convenient to fix the windlass separately on a foundation of its own. B shows an intermediate motion fixed on a pug mill. C represents a chain-driven wash mill made with wrought iron sides and frames for ready removal. D represents a wheel elevator, made of angle iron or steel, and it is claimed that this arrangement is an improvement over the ordinary form of elevators, the wearing parts being quite out of the dirt and slurry, the wear and tear is very little, and that the driving power required is much less than for pumps. F represents a clay truck, worked by the winding gear, G. A saving of time will be effected if the truck is arranged to dump automatically. The best class of clay trucks are fitted with steel axles running in chilled iron boxes. —*Building News.*

AMMONIA STILLS.

THE old fashioned method of placing ammonia water in a boiler and blowing steam into it until all the carbonate and sulphide was driven over into sulphuric acid is very properly coming to a close. It has seen its day, may have rendered good service to its employers, but it cannot hold its own against newer and improved processes and machinery.

Ten years ago the foregoing method was pretty generally adopted, but in many works dealing with ammonia salts, the gases and steam passing away from the last boiling were utilized in a tall tower filled with bricks, and down which the gas liquor was made to flow. In this form of apparatus the quantity of steam used was enormous, and we have known of instances where 30 cwts. of fuel have been required to each ton of sulphate of ammonia produced.

Moreover, the amount of lime employed with the old form of apparatus was such that one never went into a sulphate works without seeing an enormous heap of it piled up somewhere, and there were always constant complaints of the irregular character and the large quantity of ammonia left in the spent water. Nevertheless the old process was for a long time in much favor, and manufacturers did not look with approbation upon the apparent complications of the



new form of still which in 1878 was presented to their notice. We allude now to the Grüneberg still, of which there are many in use abroad, but very few in this country.

The column still has been much improved of late years, and perhaps the best design is that made by Messrs. Ashmore, Benson, Pease & Co., the gas engineers of Stockton on Tees. The accompanying illustration represents a complete apparatus guaranteed to produce twenty tons of sulphate of ammonia per week from 5° Tw. liquor of good quality, while if the liquor is 5½° Tw. it will produce 25 tons, and from 6° Tw. 30 tons weekly.

The apparatus consists, as shown, of an overhead tank, in which an adequate supply of gas water is constantly kept. From this tank it flows into a small regulating tank, fitted with a lever and float, so constructed as to keep a constant level, and so insure the regular and even run of liquor through the apparatus. The remainder of the plant consists of a tall column still, a heater of peculiar construction, containing no internal joints, the ordinary and well known saturator from which the sulphate is fished, and a vessel from which the lime is fed continuously into the still. The saturator being of the ordinary kind does not require any description, and the same may be said of the lime vessel, with the exception that it is not used for making up the lime in, but only for containing a supply of finely sieved milk for pumping into the still.

The heater into which the gas water first runs from the regulating tank above receives the waste steam and gases from the saturator, and, passing forward to the outlet, heats up the gas liquor in its passage, so that when the still is properly at work the gas water enters the tall still at 160° F., while the gases escape at 100°–120° F. If the heater is overworked the exit gases will be hotter than the liquor going into the still, and this is not desirable.

The heater is so constructed that all the joints are visible, and outside, *i. e.*, round the periphery, so that if a leakage takes place, it is at once detected. The heater is the weakest point in all other sulphate apparatus, but the one illustrated gets over every difficulty which has been urged against them. In the earlier forms of this still the tall column consisted of a series of plates perforated with a large number of quarter inch holes through which the steam passed, the liquor passing down from plate to plate by means of overflow pipes. This form is now made for special work, but it possesses the disadvantage that it will only work the exact quantity it is designed for.

It does its work admirably, but when the supply of liquor is decreased from the normal, the reduced pressure lets the liquor fall from tray to tray, and when the steam pressure is increased to meet a larger liquor supply, the steam cannot get quickly enough through the plates.

The new still, such as is illustrated here, and as made by Messrs. Ashmore, Benson, Pease & Co., overcomes all the foregoing difficulties. A four foot still in experienced hands can be made to work any quantity of sulphate, or liquor representing it, from 50 to 500 gallons per hour. When working 300 gallons per hour, the amount of ammonia left in the spent water is so small that it has to be Nesslerized, while, when working 500 gallons per hour, the quantity need not exceed 0·006 per cent., if due care be exercised in the supply of milk of lime.

The amount of fuel employed naturally varies according to the strength of the liquor operated upon, the degree of perfection of the non-conducting covering with which the still is closed, and the amount worked through the still, the point of greatest economy is that which the still is guaranteed to do. Thus a four foot still is at its greatest perfection when working so as to produce 20 tons of sulphate per week from 9° Tw. liquor, and when covered with two inches in thickness of Haack's fossil meal covering, this, together with the heating of the boiler feed water by means of the heat in the spent liquor, will require a consumption of coal equal to four cwts. per ton of sulphate; with 6½° Tw. liquor, but without the heating of the boiler feed water, the coal consumption is 6¼ cwts. per ton of sulphate, while with 5½° Tw. liquor the consumption is 7 cwts. The cost of making sulphate by means of these stills is as follows:

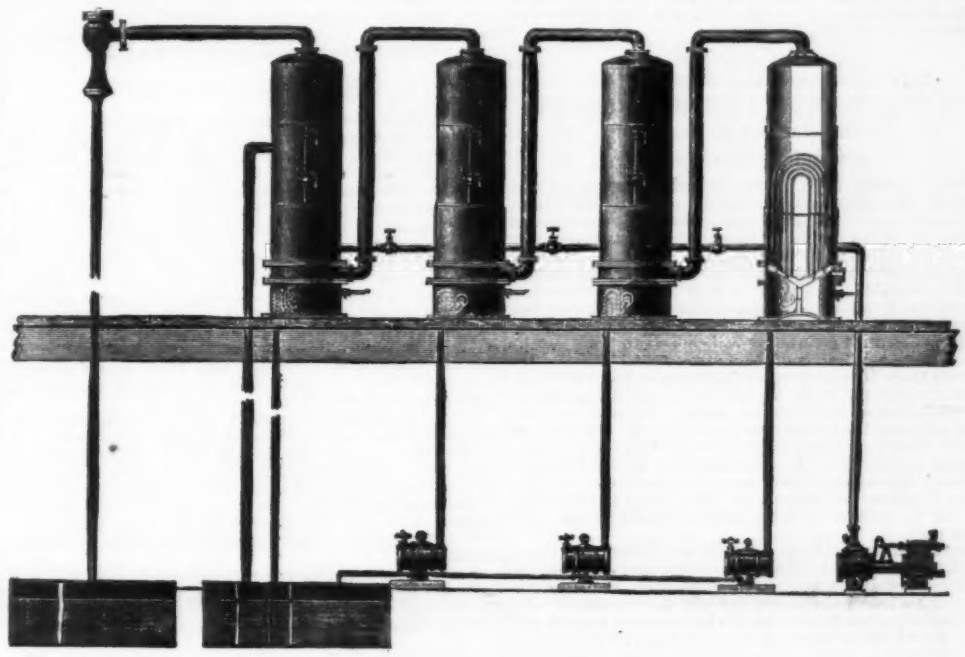
	£	s.	d.
Vitriol (ordinary chamber acid)...	1	15	0
Fuel 7 cwt. at 6s	0	2	1
Lime	0	1	6
Bags	0	3	6
Labor.....	0	4	0
	—	—	—
	£2	6	1

Of course in some places acid will be dearer than this and in other places cheaper; but we presume the price quoted will be the general average. The amount of lime will vary according to the whim of the workman; it is no use putting a large quantity of thick lime into the still. In ordinary liquors the fixed ammonia requires about 2½ cwts. to the ton of sulphate, and this may be obtained as a thin milk from about 3 cwts. of lump lime, when sieved through a screen (in the wet state) having 30 wires to the inch. This still enables the foul gases to be dealt with easily.

As a rule these gases pass away from the heater much below the temperature of boiling water, so that they require but little cooling and can be burned with ease, and the products of combustion sent into the vitriol chambers, where they make a substantial amount of sulphuric acid. Theoretically, the sulphureted hydrogen evolved from the distillation of gas water should give back about one-quarter of the vitriol needed for the conversion of the ammonia into sulphate, and this enables the foul gases to be readily and economically dealt with.—*Chem. Trade Journal.*

EVAPORATION BY MULTIPLE EFFECT.

MANY years ago a patent was taken out by John Dale, for evaporating soda liquors by multiple effect; but, like most specifications of that date, when chemical industry was young, the instructions, if duly carried out, could have led to nothing but failure. It is not clear whether Dale recognized that he was utilizing the latent heat of the steam in each successive effect, but anyhow, nothing came of the project, and soda liquors continued and continue to the present day to be boiled up in open cast iron or wrought iron vessels. In these evaporating pans about four pounds of water (not more) are evaporated per pound of fuel. So it will be seen there is great room for improvement.



EVAPORATION BY MULTIPLE EFFECT.

Evaporation, by means of steam coils placed in the liquor to be evaporated, is much more economical, as, if a boiler is not overworked, 10 pounds of water can be converted into steam of 30 pounds pressure, by the combustion of a pound of coal, and every pound of steam condensed in an evaporating coil will evaporate nearly a pound of water if the liquid is already at the boiling point.

But if we consider that 10 per cent. is utilized in heating up the liquor to its boiling point, then 10 pounds of water, condensed in the coil, should evaporate nine pounds of water from the surrounding medium, and while the coil is kept full of steam and connected with a good steam trap, there cannot be any waste of the heating agent. Moreover, in many factories hot clean water is a desideratum, and after the steam has done its work there it remains as condensed water, useful for boiler feeding or for a multitude of other purposes.

Nine pounds of water evaporated per pound of fuel may be reckoned on with a single effect where ten pounds is the work of the boiler, but it is when several stills are combined in multiple effect that the economy comes in. The latent heat of the steam from the first effect instead of escaping unutilized passes into the second effect and yields us another nine pounds there, and so on for the addition of each still or effect as the French engineers have styled them.

Upon the supposition that ten pounds of water is the duty of one pound of fuel, in the steam boilers, two effects will evaporate 18 lb. of water per pound of fuel; three effects, 27; four effects, 36; five effects, 45; six effects, 54; seven effects, 63; eight effects, 72; nine effects, 81; and ten effects, 90 lb. of water per pound of fuel.

Most of the apparatus working on this principle is very intricate and expensive, and therefore they have not come into general use, even in situations where they would have been exceedingly economical, but with a lower cost and when they become better known it is very probable we shall find a more extended application. Messrs. Joseph Wright & Co., of Tipton, have to a great extent solved the difficulty as to cost. They have adapted the well known "Berryman" feed water heater to the purposes of a multiple still and have fitted up at their works a system of four effects, in order to show them working to their intending customers. The illustration will give the reader an idea of their construction and of the small space they take up.

The woodcut shows a system of four effects; the steam is supplied from the steam boiler to the first effect, and the steam raised in the first still passes into the coil of the second, and so on throughout the series; all the water formed by condensation of the steam in the various coils is let out by means of the steam traps placed on the ground level. The liquor to be evaporated is pumped into the first effect

in a constant stream, and the flow from still to still is regulated by means of an ordinary graduated tap. The last effect is worked under a vacuum of 26 inches of mercury, at which pressure water boils at 120° F.

The vacuum is produced while absorbing the heat given off by the vapor in the last effect, and no special air pump is necessary with this system, the fall of the condensing water doing the work very efficiently.

The concentrated liquid runs out of the still automatically, so that the degree of concentration depends entirely upon the rate at which the liquid is pumped through the apparatus.

The stills are placed about twenty-six feet or more above the ground level, that is about equivalent to the second floor of a building, but the liquor supply pump and the tanks for weak and concentrated liquors are placed upon the ground floor. In this position the apparatus is as well nigh automatic as it can be, the steam is drawn away and condensed by means of a jet condenser, and a sixteen feet fall of water can be made to produce a 27 inch vacuum, when supplying sufficient water to condense the whole of the steam from the last still.

The liquor being pumped into the first still at a given rate, evaporation goes on during its passage from still to still, until it reaches the overflow from the last still, from whence it flows into the tank placed to receive it.

If space will not permit of this arrangement, an air pump of the ordinary pattern is used to extract the liquor from the last effect, and in such case the whole of the apparatus may be placed a few feet above the ground level.—*Chem. Tr. Jour.*

[Continued from SUPPLEMENT, No. 735, page 11746.]

THE SPECTRUM AND ITS DEVELOPMENT.

By GERALD F. YEO.

SPECTRO-PHOTOGRAPHY.

IT has already been mentioned that the spectra of perfectly incandescent solid and liquid bodies which emit white light and give continuous spectra are not marked by dark bands or lines. Hence such spectra cannot be distinguished from each other, all the rays being present from one end of the spectrum to the other. But this white light is used to demonstrate the absorption spectra of many substances, and hence the incandescent line cylinder or the carbon of the electric arc form essential adjuncts to the spectroscopic examination of many bodies.

From these incandescent solids, as also from the sun, we learn, further, that we see but a small portion of the undulations emitted by them. In fact, we can ascertain that the brilliant colors we see do not include all the rays that come from a bright source of light. As long ago as 1776 the heating power of the different parts of the visible spectrum was examined by the Abbe Kochon, and again, in 1798, Leslie showed the red end to possess greater heating power than any other part.

By such investigations it has been shown that there is a vast number of other rays which our eyes are incapable of recognizing. In the year 1800 W. Herschel communicated to the Royal Society the results of "experiments on the refraction of the invisible rays of the sun," by which he showed that beyond the red end of the spectrum a greater amount of radical heat could be detected by thermometers than in any part of the visible spectrum, and he concluded that the less the degree of refraction the greater the heating power of the ray, which became greatest in the "invisible thermometrical spectrum."

In 1801, Ritter, while experimenting with the action of light upon the salts of silver, not only found (in confirmation of Scheele) that the violet end was more active in this respect than the other parts of the spectrum, but that this action extended far beyond the usual limit of the violet end of the spectrum. Thus at the violet end there also existed invisible rays, which, just as those beyond the red end produced heat, possessed in a high degree the power of exciting chemical change.

These facts, which were confirmed by Wollaston and all subsequent observers, show the entire spectrum to be made up of three parts: 1. Least refrangible, heat rays. 2. Those of medium refrangibility, light rays. And 3. The most refrangible, invisible, chemical, or actinic rays.

Between the years 1839 and 1842 Sir John Herschel devoted his attention to the study of the effect of the violet end of the spectrum upon sensitive plates, and he stated that he found a new kind of prismatic light, a "lavender gray" color, beyond the violet end, while just about the same time the distinguished American, Dr. J. W. Draper, made known somewhat the same conclusion by announcing his discovery of a new latent light, distinguished only by its influence on the sensitive photographic plate.

It is chiefly to photography that we are indebted for our knowledge of these ultra-violet rays, and the steps taken for their investigation by this method have shown the enormous importance of photography in various other branches of spectroscopic work, but more especially in its application to solar spectroscopy.

In 1842 Edouard Becquerel made the earliest successful photograph of the solar spectrum, and in the following year J. W. Draper also completed very excellent photographs of the extreme ends of the spectrum.

In 1852 Prof. Stobus discovered that quartz had the power of transmitting the ultra-violet, chemical, or actinic rays much more freely than glass, and in the following year he found that the length of the spectrum of the electric spark obtained by a quartz prism and quartz lens extended to no less than six times the length of the visible spectrum.

Prof. W. A. Miller published the results of his study of the spectrum with the aid of photography and quartz prisms in the year 1862. He found he could photograph not only the visible part of the spectrum, but also a part beyond the violet six times as long as that which was visible. Mascart followed in the same line the next year, using the diffraction grating instead of the quartz prism, and photographed the whole of the recognized solar spectrum.

Since then (1874) Dr. Henry Draper, of New York, has obtained completely satisfactory photographs of the sun's spectrum extending well beyond the visual portion by means of a Rutherfurd's diffraction grating. More recently Prof. Hartley, of Dublin, has photographed the ultra-violet portion of the spark spectrum of various metals, and also the absorption spectra of many organic liquids.

Photography has thus become an indispensable adjunct to the spectroscope. By its means we can bring to light and permanently make record of lines and absorption bands which could not be detected by the eye, as they occur in the invisible part of the spectrum.

This applies particularly to the ultra-violet rays, but it is much more difficult to gain any precise information about the heating rays, beyond the red end of the visible spectrum, as they are not only invisible, but also without action on the ordinary photographic salts of silver. Besides these difficulties, glass or quartz absorbs many of these rays very completely, and is therefore inadmissible, so that lenses and prisms of rock salt have to be substituted. By working with very delicate thermo-electric arrangements, Melloni and Tyndall succeeded in measuring the relative intensity of different parts of this invisible heat spectrum and also demonstrated the selective absorption for radiant heat exerted by different solids, liquids, and gases.

Recently (1886) Prof. S. P. Langley, of the Alleghany Observatory, has shown, by the aid of an instrument devised by him, that the radiation of invisible heat rays extends below the red to an extent never previously imagined.

About the same time Capt. Abney succeeded in preparing compounds of silver sensitive to some of these rays, and has photographed a portion of the ultra-red spectrum from various sources of light and radiant heat. Much, however, remains to be done in this direction.

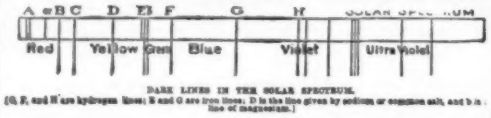
CELESTIAL SPECTROSCOPY.

It has already been stated that Fraunhofer saw the coincidence of the bright lines seen in the lamp with that of the dark D line in the solar spectrum, and he suggested that all the dark solar lines were caused by some kind of absorptive power of the suns and stars.

The early work of Brewster (1832) on the power of colored gases to absorb certain rays of the spectrum has already been referred to. In 1841 he found on burning niter "definite bright rays corresponding with some of the dark lines of the solar spectrum." "The coincidence of the two yellow rays with the two deficient ones at D, with the existence of definite bright rays in the white flame, not only at D, but at Aα and B, is so extraordinary that it indicates some regular connection between the two classes of phenomena." But at that time he came to no definite conclusion concerning this coincidence.

A very important step was made by Sir David Brewster in his discovery, published in 1834, of the fact that if the light on its way to the prism were made to traverse a colored gas, such as nitrous acid, a number of new bands appeared in addition to those permanent in the solar spectrum. He found that by heating the nitrous acid gas the lines became more numerous, wider, and darker, until the entire spectrum was made black.

From these experiments this earnest worker was not deterred by the frequent bursting of the tubes containing the gas. He prosecuted his work industriously in a mica mask and strong gloves, but only got as far as



DARK LINES IN THE SOLAR SPECTRUM.

establishing the fact that colored gases absorb certain rays of light, even when cold, which absorption becomes a much more intense and therefore a more delicate test for their presence when heated. He contrasted the bands obtained by colored gas with the solar lines, and was probably only prevented from arriving at the right explanation of the latter by his conviction that the atmosphere of the earth was an important factor in their production.

Some ten years later the distinguished chemist, Prof. W. A. Miller (1845), confirmed Brewster's observations concerning the spectra of iodine, bromine, nitrous acid, and also gave the absorption spectra of other gases. He examined the flame spectra of chloride of copper, boracic acid, nitrate of strontium, and chlorides of calcium and barium, using the oxyhydrogen jet to produce the flame; and he concludes: "It may be interesting to remark, in connection with the speculations on the absorptive action of the sun's atmosphere, that if the solar light be transmitted through a flame exhibiting well-marked black (bright?) lines, these lines reappear in the compound spectrum, provided the light of day be not too intense compared with that of the colored flame. . . . It would, therefore, appear that luminous atmospheres exist in which not only certain rays are wanting, but which exercise a positive absorptive influence upon other lights." If we read "bright" for "black" in the foregoing sentence, the statement corresponds with our present views of the solar lines. As no black lines exist in the spectra referred to and drawn by Miller, the word may have been a misprint.

After the work of Brewster, W. H. Miller, and W. Allen Miller (1845) on the power of vapors at different temperatures to absorb certain of the colored rays of the spectrum, little was done in this respect for many years.

In 1849 Foucault showed that the light of the electric arc when passed through the sodium flame caused a dark band in the exact position of the bright bands seen when the spectrum of the flame itself is examined. He satisfied himself that the double brilliant (sodium) lines of the arc coincided exactly with the double dark lines of the sunlight, and that the electric arc light placed in the path of a ray of sunlight absorbs the D rays so that the D line of the sunlight is considerably intensified when the two rays are exactly superposed. "Thus," he says, "the arc affords us a means which emits on its own account the D rays, and at the same time absorbs these rays from other sources."

Although many expressions in the works of the foregoing authors seem clearly to indicate that they recognized a relationship between the production of the bright bands of flames and the dark bands of the absorptive spectra, and that they were aware that the sun's atmosphere had absorptive influence upon some rays of the light of our luminary, they did not seem to connect the coincidence in a conclusive manner.

The man who seems to have been the first to recognize the real importance of this coincidence was Angstrom. In 1853 he states that a body readily takes up the light having those wave lengths which it can itself emit, and elsewhere he distinctly speaks of some of his spectra being a reversal of the solar spectrum. He says, "as according to the fundamental principle of rules a body absorbs all the series of oscillations which it can itself assume, it follows from this that the same body, when heated so as to become luminous, must emit the precise ray which at a common temperature is absorbed." Having contrasted the electric and solar spectra, and pointed out the effects of the atmosphere, he says: "The analogy between the two spectra may, however, be more or less completed when allowance is made for all these minuter details. Regarded as a whole, they produce the impression that one of them is the reversion of the other. I am, therefore, convinced that the explanation of the dark lines in the solar spectrum embraces that of the luminous lines in the electric spectrum." He describes the characteristic spectra of oxygen, carbon dioxide, nitrogen dioxide, hydrogen, carbureted hydrogen, and nitrogen. This paper, which was translated in 1855 in the *Philosophical Magazine*, did not attract the attention that these important principles really deserved.

KIRCHHOFF'S WORK.

It remained for Kirchhoff in 1859 to show the true bearing of these facts, and to explain the true significance of the relation of the bright bands of flames and the dark lines of the solar spectrum. The great physicist, working at Heidelberg, with his equally renowned colleague, Bunsen, the chemist, seems to have carefully assimilated all the previously unconnected facts, and by actual experimental investigation placed the matter upon a sure basis, and gave an explanation of the many doubtful points which seem to have hung like a veil between all previous observers and the whole truth.

The way in which Kirchhoff made the first observation, convincing him that he held the key to the solution of the problem of the constitution of the sun, cannot be given more tersely than in a translation of his own words. He says: "In order to test in the most direct way possible the frequently asserted fact of the coincidence of the sodium lines with the lines D, I obtained a tolerably bright solar spectrum and brought a flame colored with sodium vapor in front of the slit. I then saw the dark lines, D, change into bright ones. The flames of a Bunsen lamp threw the bright sodium lines upon the solar spectrum with unexpected brilliancy. In order to find out the extent to which the intensity of the solar spectrum could be increased without impairing the distinctness of the sodium lines, I allowed the full sunlight to shine through the sodium flame, and to my astonishment I saw that the dark lines, D, appeared with an extraordinary degree of clearness."

That is to say, by lighting up the dark lines with a sodium flame, they became darker, as if by bringing a bright light in front of a shadow one made the latter appear more distinct, instead of disappearing.

"I then," he goes on to say, "exchanged the sunlight for the oxyhydrogen lime light, which, like incandescent solid and liquid bodies, gives a spectrum containing no dark lines. . . .

"When this light was allowed to fall through a suitable flame colored with common salt, dark lines were seen in the spectrum in the position of the sodium lines."

Thus, by the combination of the bright sodium lines with the bright continuous spectrum, he obtained dark bands at D. In this experiment he practically manufactured a portion of the solar spectrum, for, from a continuous spectrum in which previously there were no gaps or shadows, he made a dark line appear by the interposition of a sodium flame, and thus changed the continuous to an absorption spectrum.

Thus a simple explanation of the Fraunhofer lines in the solar spectrum struck Kirchhoff. The sunlight having to pass through certain glowing vapors was robbed of some of the colored rays of light, and thus, instead of giving us the continuous spectrum of the glowing nucleus, it presents a complex absorption spectrum.

Kirchhoff next tried if the same phenomenon occurred with other bodies. By making the light from an incandescent solid pass through flames colored with various other substances, such as lithium, calcium, barium, strontium, he showed that dark lines invariably appeared in the position of the characteristic bright bands of the metal used, owing to the absorption of some specific rays by the glowing vapor.

It may be well to consider here how this absorption is accomplished by glowing vapors. It must first be understood that the molecules of a highly heated gas do not vibrate at every conceivable rate, but only at certain rates or frequencies determined by the nature of the elements in the gas. Thus, for instance, incandescent sodium vapor has a certain definite rate or period at which it readily vibrates, but refuses to vibrate quicker or slower, and this character of vibration is seen in its light, which consists only of a pure yellow ray. When, therefore, the light coming from incandescent sodium vapor is examined by means of a spectroscope, a bright yellow double line alone is seen; there is no red, green, blue, or other light, and the exact position in the spectrum at which the yellow line appears is constant, as it depends upon the wave length of the light given out by the sodium vapor, which is invariable. Most elements do not give rise to so simple a set of waves as sodium, and, therefore, show a more or less great number of bright lines, but each element has its characteristic lines, which are distinctive.

The same law holds good with regard to those waves in air which we call sound, and the phenomena may be readily followed in an example taken from the air waves.

If a note be sung into an open pianoforte, some of the wires respond with the same note, because those wires which give out that particular note are thrown into sympathetic vibration, and take up or absorb vibrations of the same frequency as those they emit when struck, while the other wires remain at rest, unless another note having their specific frequency of vi-

bration or pitch is sung. All the notes of other wave frequency than that of a given wire pass it by without influencing it, *i. e.*, without being absorbed by it.

In the same way, when sodium vapor, which vibrates at such a rate as to produce yellow light corresponding to the double yellow line in the spectrum, is placed in the path of a beam of strong white light, it takes up or absorbs only the vibrations of its own pitch or frequency, while it is unable to respond to other vibrations quicker or slower than it itself gives out. These other waves therefore pass through the sodium vapor unimpeded, and produce the red, orange, green, blue, and violet in the spectrum, while that part of the yellow in the spectrum produced by sodium light is absorbed, and hence dark lines appear at that point of the spectrum corresponding to its rate of vibration. This absorption of sodium light by sodium vapor can be readily seen by using a spirit lamp in a dark room, with a wick containing common salt (sodium chloride). This, of course, gives the yellow sodium light; but if behind it be placed a Bunsen burner with a small piece of sodium held in the flame, the sodium in the flame of the spirit lamp absorbs the light coming from the hotter Bunsen flame, and appears quite dark when viewed against it. Thus the sodium spirit flame appears as a non-luminous flame against the brighter flame of sodium with gas and air.

This, having been proved by exact experiment, shows how the spectroscope can be used as a delicate and certain means of analysis; for if the lines in the spectrum of a substance of unknown composition agree exactly in position with those of some known element or elements, it may be safely concluded that such elements are present in it.

Kirchhoff at once concluded that the dark lines in the solar spectrum might in a similar way be caused by the atmosphere which surrounds the central body of the sun absorbing certain kinds of light waves before they pass into space; and so by comparing the positions of those dark lines with the bright ones given by the incandescent vapors of known elements, their exact agreement furnishes proof of the existence of such elements in the sun's atmosphere in a vaporous condition. By making these exact comparisons he and subsequent workers have positively demonstrated that a number of elements well known on our planet are present in the sun, thus converting a vague belief that appears only to have become matured in the bold minds of Angstrom, Stokes, and Sir William Thomson into a fact universally accepted.

Bunsen and Kirchhoff proved by direct experiment that not only did the bright sodium flame cause absorption which coincided with the dark D line of the solar spectrum, but that many other glowing vapors caused absorption of exactly that part of the continuous spectrum at which the bright bands characteristic of their spectra held their position.

Kirchhoff then made the following generalization, which was previously recognized to be true with regard to heat, as to the reception and emission of luminous rays: "Every substance which emits at a given temperature rays of certain orders of refrangibility possesses the power at that same temperature of absorbing rays of those same orders of refrangibility."

CONSTITUTION OF THE SUN.

Using the bright line spectra of the vapors of several metals in the electric spark, compared with the solar spectrum by means of the reflecting prism already referred to, Kirchhoff found that the bright lines of many other bodies, as well as sodium, had in several cases exact coincidence with the dark lines in the spectrum of sunlight.

In the case of iron, which, as a glowing gas, gives a spectrum with a great number of bright lines (460), the coincidence is most remarkable, for in the solar spectrum dark lines are found to occur corresponding in every particular, number, width, position, etc., with the bright lines of the iron spectrum. With such multiple and exact coincidence it becomes practically impossible that the two phenomena should not depend on a common cause. Examined by the law of probabilities, the odds against such a coincidence resulting from chance would be 1,000,000,000,000 to 1.

"The observed phenomenon," says Kirchhoff, "may be explained by the supposition that the rays of light which form the solar spectrum have passed through the vapor of iron, and have suffered from the absorption which the vapor of iron must exert." Iron cannot well exist in our earth's atmosphere in sufficient quantity to cause these clear lines, but with the high temperature known to exist in the sun it is quite probable that substances such as iron do exist as vapors in its atmosphere. Indeed, this seems the only rational conclusion to be drawn from the facts mentioned.

In 1861, Kirchhoff had given the following list of substances as present in the sun.: Sodium, iron, calcium, magnesium, nickel, barium, copper, zinc (doubtful), cobalt, and also a long list of elements which he believed to be absent from it.

The coincidences in the positions of the dark Fraunhofer lines of the solar spectrum with the bright lines in the spark spectra of various elements were exhaustively examined and recorded by Angstrom in a table of elements published in 1869, adding hydrogen and manganese, while Thalen, in a separate memoir, gives a similar list (to which titanium is added) as representing elements present in the sun.

But it must be remembered that these observers employed the method of simply directing the horizontal spectroscope so as to receive the sun's rays guided by a heliostat on its slit, and therefore the light received was the mixed radiation of the various parts of the sun, or represents an integration of all the various rays given out by that body. Thus the existence of several elements was lost sight of, and only a general idea of the constitution of the sun could be deduced. The result even thus arrived at was, however, very remarkable, and sufficient to disprove conclusively the theory suggested by Sir W. Herschel in 1777, in which he supposes the outer envelope of the sun to be the essentially luminous portion, the inner parts being dark and consequently cool.

Since the lines seen in the solar spectrum are dark, they evidently indicate an absorption by vapors of the elements causing them, of those particular rays from what would otherwise be a continuous spectrum. Hence Kirchhoff's conclusion that the sun consists of a nucleus of highly compressed and intensely heated matter, probably entirely or at least partially solid or liquid. This central mass is completely enveloped by an atmosphere of relatively cooler—though really very hot—vapors. The light starting from the central nucleus would consist of waves of every wave length, and cause a continuous spectrum, but in passing through the various vapors of elements, rays of certain wave lengths would be selectively absorbed, each gaseous element absorbing the same kind of light as it was found to emit when heated by the electric spark.

This then became the only tenable hypothesis, and while more recent work has furnished fuller and more detailed information, it has consistently confirmed and developed the theory thus originated.

In 1862 Stokes, using the electric spark instead of a slit, found that the bright lines due to the metal of the poles did not extend the entire length of the spark, but only existed near the poles, while the air lines stretched right across between them. Subsequently Lockyer and Frankland determined the lengths of lines in the spectra given by many elements with the electric spark and arc.

An important advance in the solar spectroscope was made in 1866 by N. Lockyer. It consisted in the use of a convex lens placed in front of the slit of a spectroscope at the right distance to give a sharp image of the sun on the slit. Thus, instead of allowing the rays of light to enter the slit indiscriminately, they are brought by the lens to a focus so as to form an image of the sun. Those rays which are given out by the edge of the sun will be collected at the edge of its image, so that by examining in succession the different portions of this telescopic image we can examine separately the light emanating from the various parts of the sun's disk and surroundings.

Now, from simple physical considerations, it will be evident that in the sun's atmosphere the vapors of the densest and least volatile metals would naturally take up the lowest position, *i. e.*, nearer the surface, the less dense elements, such as sodium and hydrogen, lying outside. It became then of great interest to obtain a clear view of these less dense layers of the solar atmosphere, apart from those of the more brilliant nucleus. This was to be looked for in a solar eclipse.

Near the metallic pole the vapor of the metal will necessarily be densest, and will thin out as the distance from the pole increases; thus those lines which are only furnished by a dense vapor of the element at a high temperature will be short, although the expanded vapor may extend further from the pole and give other more frequently observed lines in the spectrum. The long and short lines thus produced are, on account of their mode of formation, capable of giving valuable results respecting the density and temperature at which they are developed with various elements; for with an increase of heat in the spark the lines will lengthen, or if two elements of different volatility be used, the more volatile one would yield the longer lines.

During a total eclipse the margin of the eclipsed sun is seen to be bordered by certain reddish colored projections or prominences, which are further surrounded by a diffused light extending a great distance from the body of the sun, and known as the corona. On examining these prominences with the spectroscope, they are found to yield bright lines, because the bright body of the sun being hidden by the moon, the prominences send their own light to the observer. The positions in the spectrum of these bright lines prove the prominences to consist largely of incandescent hydrogen. This was definitely proved by the various eclipse expeditions on August 18, 1868. Janssen was the first to record, by telegraph from India, that the prominences consisted of enormous columns of incandescent gas, and gave a bright line spectrum. The confirmation thus afforded to Kirchhoff's theory of the constitution of the sun was made still more complete by the observations of Prof. Young in the total eclipse of 1870, in which, at the moment of obscuration and for two or three seconds afterward, he saw all the Fraunhofer lines reversed as bright lines, thereby proving that when the extreme margin of the sun was itself viewed, the light of the photosphere being cut off, the ordinary solar absorption spectrum vanished, and its place was taken momentarily by the bright line spectrum corresponding to the several constituents of its outer layers.

Thus these eclipses showed two important facts: first, that the vapors of the metals which give the dark lines are really intensely heated, and if allowed to shine by their own light without a brighter light being transmitted through them, they give brighter lines in the same positions as the dark lines; and secondly, that around the sun and above the vapors of the ordinary metals a vast ocean of incandescent hydrogen exists, the average depth of which is some 5,000 to 6,000 miles, which is in places projected with immense velocity to heights of 60,000 or 70,000 miles.

But though much can be learned from a good eclipse, the combination of a total eclipse and of weather favorable for its observation is a rare occurrence, and the duration of the time when the photosphere is quite covered, or of "totality," is so short as to leave little time for accurate spectroscopic observations.

Lockyer, in 1866, had suggested the spectroscope as a means of viewing the solar prominences when the sun is not eclipsed, and about the same time Huggins announced the same idea. But, as a matter of fact, Janssen was the first who actually saw the lines due to the prominences in broad sunlight. This he did the day after his observation of them in the eclipse of 1868 at Guntoor. The great difficulty lay in the fact that the illumination of our atmosphere by direct sunlight is so strong that although only the edge of the sun be examined, the atmospheric illumination is strong enough to give a general spectrum, which masks the bright lines of the prominences. This difficulty has been surmounted in the following way:

When the light consisting of a mixture of diffused general sunlight and the special light given out by the solar prominences is transmitted through a prism, it is spread out as a spectrum, but the lines from the glowing prominences may not be visible with the light of the continuous spectrum as background; but if the beam of light from the prominences is passed through a succession of prisms—while the continuous spectrum consisting of every tint is more and more spread out as it passes through each prism, and is therefore rendered much feebler—the monochromatic lines due to the prominences are only separated wider apart, and, retaining nearly all their original brightness, become distinctly visible. Then, in order to see the form and size of the prominence, one special bright line is selected, the telescope fixed so as to view that part of the spectrum, and the slit of the spectroscope is made wider so as to allow the whole of the prominence to come into view. Huggins modified this method by using colored glasses to cut off as many rays as possible except the color of the line he was observing, and Janssen, Lockyer, and Zollner conceived the idea of giving the slit of the spectroscope a rapid rotation, instead of making it wider, so that the different parts of the prominence could be seen in rapid succession, and thus give an impression of its form and extent; but this latter suggestion has not been found convenient in practice.

It will be evident from what has been said before that if a high dispersion spectroscope be employed in the way described, with its slit turned radially as regards the sun, and the extreme edge of that body be focused on the slit, in the outer part of the spectrum the bright lines of the chromosphere will be visible, while the inner part will give the ordinary absorption spectrum, with some of the dark lines of which the bright lines of the chromosphere will be continuous. From the distance outward that the bright lines extend one can judge of the depth of this layer of incandescent hydrogen, while the length and position of the lines below will help to fix the limits to which the sea of vapors underneath the prominences extend, and the order in which the elements are distributed.

Besides this application of the variation of the length of the lines in mapping out the sun's atmosphere, Lockyer found that those lines of any element which are longest in the spectrum of the electric spark and most persistent are just those which are most certain to be represented by dark absorption lines in the sun's spectrum, and those short lines only seen where the vapor is very dense are frequently absent from the solar spectrum. In this way he has been able to add several more elements to the list of those existing in the sun's atmosphere. The complete list up to the present time comprises the following elements: Iron, titanium, calcium, manganese, nickel, cobalt, chromium, barium, sodium, magnesium, copper (?), hydrogen, palladium, vanadium, molybdenum, strontium, lead, uranium, aluminum, cerium, cadmium, and oxygen.

By attacking the sun locally, the sun spots, about which such diverse theories have from time to time been started, have received a satisfactory explanation. Lockyer and subsequently Huggins and Father Secchi found that the spectrum of the spots resembled the usual solar spectrum, only the dark lines were thicker and darker, thus showing that a vapor of a spot is more powerfully absorbent and therefore at a much lower temperature than the rest of the vaporous surface. Secchi, indeed, believes that he has seen the spectrum of water vapor in these spots, but whether this be so or not, little doubt exists that these spots represent inrushes of cooled vapors, through which much less light from the nucleus finds its way to our regions of observation.

STELLAR SPECTROSCOPY.

Huggins and Miller, in England (1864), and Father Secchi, of Rome, were the first to direct special attention to stellar spectroscopy.

The spectra of stars bear generally a strong similarity to the solar spectrum, being continuous spectra crossed by dark lines.

Owing to the small amount of light received from a single star, it is necessary to use a large lens to condense as many rays as possible. From its immense distance the star appears only as a point of light without extension; it is therefore necessary to use a cylindrical lens in order to spread out the rays into a line of light which can yield a spectrum having a visible breadth. On account of the feebleness of the light, fewer prisms have to be used than with the sun.

Secchi has classified stars into four groups which approximately represent the different colored stars. The first division consists of white stars, such as Sirius, Vega, and (A.) Lyræ, giving a spectrum rich in the blue rays and crossed by four dark lines due to hydrogen, together with other finer lines due to other elements. These stars, which are believed to be at an exceedingly high temperature, are evidently enveloped in a dense atmosphere of hydrogen, which, judging by the thickness of the lines, must be under considerable pressure.

The second class, consisting of yellow stars, is that to which our sun belongs, and the solar spectrum may be taken as representing the kind of absorption generally seen in this class, although the elements actually found differ somewhat in certain individual stars. Thus Aldebaran contains hydrogen, sodium, magnesium, calcium, iron, bismuth, tellurium, antimony, and mercury.

The third class, comprising chiefly the red stars, give a spectrum in which, if moderate dispersion be used, dark bands and flutings appear. These flutings or channeled space spectra indicate that a more powerful absorption is taking place in the star's atmosphere, and, therefore, that it is at a much lower temperature than in the case of those previously mentioned, and these channeled spaces, according to Lockyer, indicate that the elements have aggregated into molecules, the temperature having fallen below that point at which they can exist only as uncombined atoms.

The fourth class comprises several small stars which show three bright bands with dark absorption spaces between. They have been supposed by some to contain carbon, which gives a complex banded spectrum, but Huggins considers the position of the bands to be different from those of carbon, so that their true constitution and physical state remains for the present undecided.

Some stars have been found to give the bright lines of hydrogen. This was so in the case of one star that appeared in 1866. In May of that year a star, previously unknown, or at least unnoticed, which must therefore have been of a very small size, suddenly blazed out and became for a short time very brilliant, gradually fading away until it again became a minute star invisible to the naked eye. Huggins and Miller were enabled to make a number of observations of its spectrum, and they found that superposed upon the dark line absorption spectrum common to all the stars they had hitherto examined were the bright lines of hydrogen. Secchi has since found that several of the telescopic stars have these bright lines in their spectra.

The moon and planets, shining as they do by reflected sunlight, give the solar spectrum, modified, however,

in some cases by the absorption that has occurred in their atmosphere. Fraunhofer in 1823, Brewster and Gladstone in 1860, and later Huggins, Miller and Janssen, all agree in stating that the lunar spectrum is the same as that of the sun. This conclusion is in entire accord with observations on the occultations of stars which have shown the absence of any refraction at the moon's edge, and therefore render certain the absence of a lunar atmosphere. But although the moon is destitute of any appreciable atmosphere, certain planets have long been believed to possess one, and in 1864 Huggins discovered some dark absorption lines in Jupiter's spectrum, some of which agree in position with those due to aqueous vapor. Mars and Saturn also appear to have atmospheres containing aqueous vapor, while the outer planets, Uranus and Neptune, whose spectra have been examined by Secchi and Huggins, show very remarkable absorption lines. Uranus gives two broad black bands and a general absorption in the yellow, while Neptune shows six distinct absorption bands.

It has been suggested, and the view is now held by many, that these outer planets are still at a comparatively high temperature, which would, of course, account for their dense atmospheres and strong absorption.

Next to the stars and planets Huggins turned his attention to those faint and cloud-like bodies of various form and vague outline termed nebulæ.

In 1864 he examined a small nebula in the constellation Draco, and found, greatly to his surprise, that instead of getting a spectrum like those yielded by any star, there appeared one consisting of three bright lines only. Of these three lines one occupied the position of the F line of hydrogen; another, the brightest, coincided with the strongest line in the spectrum of nitrogen; while the third was not coincident with that of any known element.

The question naturally arose, Why do not the other lines of hydrogen and nitrogen appear if those two lines be really due to those elements? Huggins solved the difficulty by observing that the nitrogen, when rendered incandescent and the light greatly diminished by viewing from a considerable distance in air, gave only the bright double line in the green, with which this line in the nebula corresponds. Similarly, if the spectrum of hydrogen be reduced in intensity, the line in the blue will remain visible after the red and the lines more refrangible than the blue have disappeared. Hence, in all probability, those nebulæ yielding this bright line spectrum consist largely of incandescent hydrogen and nitrogen, and are therefore mainly gaseous.

Other nebulæ examined by Huggins yield faint continuous spectra, in which the light is too feeble to show whether any dark lines are present or not.

Those nebulæ that with greater telescopic power have been resolved into clusters of distinct stars show this continuous spectrum. Probably this difference of spectrum indicates an entirely different constitution in the two classes of nebula, those yielding the bright bands consisting of vast quantities of incandescent gases in more or less continuity and, it may be, destined to give rise to new solar systems in process of time; while the other class, many of which have now been shown to consist of enormous numbers of stars, probably separated by millions of miles from each other, only appear as luminous clouds in telescopes of moderate power, owing to their immense distance from the earth.

The spectroscope in the hands of Huggins and Secchi has also given us a great deal of information about those strange visitants to our solar system, *i. e.*, comets. A comet as seen in a telescope usually shows a bright head and one or more appendages called tails, the head containing a very bright spot, or nucleus, which in some comets is surrounded by concentric envelopes, while in others bright jets appear to issue from it; the tails, which in almost all comets extend an enormous distance from the head, are subject to rapid changes, usually elongating with great rapidity as the comet nears our sun.

The spectroscopic result obtained by Huggins shows that instead of giving a spectrum of bright lines or of dark lines the head of a comet yields one of the channeled space type, in which bright bands are separated by dark spaces. Further, these bright bands coincide almost exactly in position with the spectrum of carbon or hydrocarbon, so that in the head of a comet the luminous substance most probably consists of a gaseous hydrocarbon in a state of low incandescence.

The tails of comets, on the other hand, give feeble spectra in which many of the lines of the solar spectrum can be distinguished; hence it may be concluded that they shine mainly, if not entirely, by reflected sunlight.

So much exact knowledge having already been brought to light by the use of the spectroscope, one might perhaps be inclined to feel satisfied that its work had come to an end; but it would be safer to indorse even to-day the prediction enunciated more than fifty years since by the bold mind of Sir David Brewster, who foretold a great future for the spectrum in these words: "I am persuaded it will open a field of research which will exhaust the labors of philosophers for centuries to come."—*N. Y. Sun.*

SEEING TO A DISTANCE BY ELECTRICITY.

A CORRESPONDENT to *La Lumiere Electrique* thus comments upon M. L. Weiller's paper, which appears in *Le Genie Civil*, vol. xv., p. 570:

The writer endeavors to solve the important question of vision to a distance by electricity, by means of a combination consisting of a selenium cell, a gas telephone, and revolving mirrors, forming a special apparatus which he designates a phoroscope, and which we will briefly discuss.

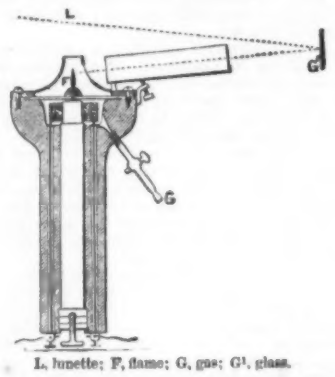
The question of vision to a distance by electricity is governed by the two following fundamental principles. In order to get the impression of the form, outlines, and details of one or several ojects, it is not necessary—1. That the eye should receive all the rays proceeding from it. 2. That it should receive, at the same time, the luminous rays necessary for vision.

Some very simple examples will demonstrate the first principle. We can see an object very clearly through wire gauze, and the image is perfect if the interstices are large and the wire fine. Carpets and mosaic seen at a certain distance do not seem to be formed of a number of parallel lines or by the juxtaposition of little stones. An engraving, a picture, and especially a chromo-lithograph, show at a distance no discontinuity in the work, although the engraving is composed of lines and the chromo-lithograph of separate little dots.

We see thus that it is possible to have a sufficiently clear perception of an object by the vision of a system of more or less luminous lines forming a kind of pattern.

The second principle is quite as well known and as deduced from the duration of the luminous impressions upon the retina, a period of about $\frac{1}{10}$ of a second.

A series of impressions succeeding one another in a very short time produces the effect of simultaneous impressions, and it follows that in order to perceive the image which we have called the pattern, it is sufficient to receive the luminous impressions of the different



L, lunette; F, flame; G, gas; G¹, glass.

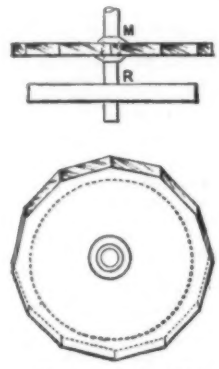
FIG. 1.

lines that constitute it in an interval of time less than $\frac{1}{10}$ of a second.

It was by taking this principle as a basis that Lissajous studied from an optical point of view the vibratory movements of bodies. His experiments are so well known that we need not enter into them here.

Lissajous' curves are produced in a rectangular portion of a picture. If, on the other hand, this object possesses the power of lighting, all the rays proceeding from the space occupied by the curve will, in an excessively short space of time, converge at one point after having been subjected to a double reflection on the mirrors of the two tuning forks that were employed for this experiment.

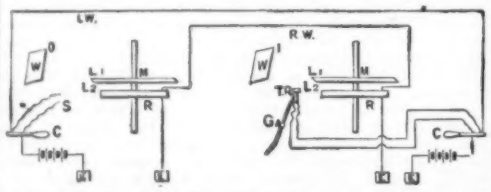
We may substitute for these forks any movable system whatever, bearing a series of mirrors arranged in



M, mirrors; R, regulator.
30 revolutions per second; 300 glasses on the sides instead of 12.

FIG. 2.

such a manner that the displacement of each of them brings upon the same straight line all the rays projected from a portion of an illuminated object. Let us suppose these mirrors to be placed on a circle turning upon an axis perpendicular to its plane, and each of them making a different angle near 90° with this plane. To each mirror there will be a corresponding series of parallel lines in the picture, and if the rotation is sufficiently rapid, all the rays proceeding from the object represented in the picture will meet at the same time, in as short an interval of time as required. It is thus possible to bring to one point all the luminous rays proceeding from a pattern, and each portion of the image thus producing its impression upon the retina in succession, it is sufficient that the interval in



L. W., line wire; R. W., regulator wire; L_1, L_2, lenses; M, mirror apparatus; R, regulators; O, object; I image; S, selenium transmitter; C, commutators; G, gas; T, R, telephone receiver; E, earth.

FIG. 3.

which these impressions succeed one another should be sufficiently short for them to be rendered simultaneous.

The transformation of the luminous waves into electric currents is performed by means of a radiophonic receiver forming part of an electric circuit. This receiver may be a cell of selenium lamp black, hydrogenated palladium, etc., the resistance of which varies with the quantity of light received. The different portions of the pattern will act differently according to the quantity of light emanating from them and in an interval of time less than $\frac{1}{10}$ of a second; the variations of resistance of the circuit will correspond to the image observed.

In order to solve the opposite problem, *i. e.*, to extract this image from the circuit at the receiving station, the writer proposes to employ the gas telephone, which is an instrument of extreme sensitiveness. It consists of an ordinary telephone (Fig. 1) in which the portion comprised between the plate, the bobbin, and the inner sides is in communication with a gas pipe; the vibrating membrane is pierced in the center with a little hole, through which escapes the gas which is lighted; this little flame will undergo a variation in brilliancy at each movement of the membrane, and it will produce a continuous succession of rays similar to those arriving upon the radiophonic receiver. In order to show them and form an image similar to the pattern, a system of mirrors is employed (Fig. 2) similar to that used at the first station, but acting in the reverse way. It is evident that these two apparatus must act synchronically like the Hughes and Baudot regulators employed in telegraphy.

Station 2 will reproduce upon a sheet the lines taken upon the image at Station 1.

The writer gives the name of phoroscope to an apparatus of this description, the different parts which we have described being combined according to the plan shown in Fig. 3. The image that we wish to transmit is broken up into a series of parallel lines, the different points of which act in succession upon a selenium cell, making the intensity of the current connecting the two stations vary. These variations in electrical intensity are transformed by the gas telephone into variations of luminous intensity, and the successive changes of brilliancy of the little flame are projected upon a sheet at points corresponding to the various points of this sheet.

Theoretically, nothing can prevent this double transformation of luminous intensity into electric insensity, bnt the realization of the experiment is surrounded with difficulties which make us fear that it will be long before a practical phoroscope is produced, but this should not discourage enterprising and persevering physicists. —*Electrical Review.*

THE DETERIORATION OF ELECTRICAL CONDUCTORS.

IN an interesting communication to *La Lumiere Electrique*, M. Firmin Larroque gives an account of some of his observations on the deterioration of copper conductors by the long-continued passage of strong currents of electricity through them. His attention seems to have been first called to the question in 1884, when he examined the electrical and mechanical properties of some pieces of electric lighting cables that had been in use for some years. One specimen—a portion of a cable which had conveyed electricity to a lighthouse lantern for a period of twenty years—gave very striking results. It was extremely brittle and broke in fragments under the hammer, while its fractured surface resembled in all particulars that of electrolytic copper. The current through this cable had not been in any way excessive, nor had it been subjected to any heavy mechanical straining. Similar though less marked results were obtained with other cables, which had been in use for shorter spaces of time.

The currents in all these cases were direct, but a portion of the secondary circuit of a small Ruhmkorff coil, for many years employed in igniting the gas of a Lenoir gas engine, gave M. Larroque an opportunity of examining the effects produced by an alternating current. This coil had become very brittle, and broke up during the process of unwinding; its electrical resistance, moreover, had increased about 31 per cent. during the years it had been in use. M. Larroque then determined to make some systematic experiments on this subject. He endeavored in the first place to determine whether the long-continued passage of a powerful current of electricity caused any expansion of the wire, and secondly whether and in what degree it altered the elastic properties of the material. For each experiment nine pieces of copper ribbon 10 mm. broad and 0·3 mm. thick were provided, and for the second of the experiments, each specimen was bent into a zigzag of 80 bends.

One end of the zigzag was attached to a rigid support and from the other a weight of 10 grammes was hung. Some of the specimens were hard-drawn copper, and the others were made from the annealed metal. Through seven of the nine specimens a current, in some cases alternating, in the others direct, and ranging in different cases from 0·5 to 2 amperes, was passed, while the other two specimens, one of which was hard-drawn and the other annealed, were kept as standards, so as to eliminate any changes arising from causes unconnected with the passage of an electric current. Should the elasticity of the specimens be altered by the current, the position of the 10 gramme weight would, of course, vary correspondingly, and means were taken for the accurate estimation of such changes. During the first nine months of the four years over which the experiments have been prolonged, the observations showed a want of uniformity, but since then have been very regular, and the results now published show that the elastic properties of the wires have been very considerably changed. This variation takes place the more rapidly with strong than with weak currents, and with alternating than with direct.

NOTE ON THE PHOTOGRAPHIC SPECTRA OF URANUS AND SATURN.*

By WILLIAM HUGGINS, D.C.L., LL.D., F.R.S., and Mrs. HUGGINS.

Uranus.—In 1871 I had the honor to communicate to the Royal Society an account of the examination of the visible spectrum of Uranus.†

The visible spectrum of this planet is remarkable, as it is seen to be crossed by several strong lines of absorption. Six of these dark bands are shown in a diagram which accompanies the paper, and their approximate positions in the spectrum are given. The spaces between the dark bands appear bright by contrast, and might suggest at first sight bright bands. I was unable to use a slit sufficiently narrow to enable me to

* Read before the Royal Astronomical Society.
† 'Roy. Soc. Proc.,' vol. xix., p. 488.

determine whether the bright parts of the spectrum contain the Fraunhofer lines, which would be the case if Uranus, like the other planets, shines by reflected solar light.

The spectrum of this planet was carefully examined in 1872 by Vogel,* whose results are in accordance with my earlier ones. He observed some fainter lines or bands, in addition to those given in my paper. Vogel was unable to obtain evidence of the Fraunhofer lines. His observations agree with mine in placing a dark band at the position of F in the solar spectrum.†

In consequence of the Fraunhofer lines not having been seen, a presumption has arisen that Uranus may shine, in part at least, by emitted light.

It appeared to me that this question might be answered by photography. With an exposure of two hours, I obtained on June 3 a photograph of the spectrum of the planet from a little above F to beyond N in the ultra-violet. A pair of sky spectra, one on each side of the planet's spectrum, were taken on the same plate.

The spectrum of Uranus, though fainter, shows all the chief Fraunhofer lines seen in the comparison spectra, and is clearly solar. I have not been able to detect any indications of bright lines, nor of any strong bands or groups of absorption, such as those in its spectrum from F to C.

There can be no doubt that the spectrum of Uranus, at least, from a little above F to beyond N in the ultra-violet, is due to reflected solar light. I have not yet been able to re-examine the visible spectrum of the planet.

Saturn.—In 1864 I gave an account of an examination of the visible spectrum of this planet and its rings. In my paper on the "Photographic Spectra of Stars,"‡ I described the photographic spectra of Venus, Jupiter, and Mars. About a year later I took a photograph of the spectrum of Saturn and his rings, but as it did not present any new features, but was purely solar, I have not given any description of it.

The favorable position of Saturn this year for obtaining a photograph in which the spectra of the ansæ of the rings could be seen distinct from the spectrum of the ball and of the paft of the ring crossing it, determined me to take some photographs of the planet and its rings.

I have adopted the plan described in 1880, in which the planet is photographed while the sky is sufficiently bright to give a faint daylight spectrum on the plate. Any additional lines or other modifications of solar light due to the planet's atmosphere can in this way be easily detected.

In the photographs taken this year the slit was so placed upon Saturn that the spectrum consists of three distinct parts, the middle part being formed by the light from the ball, and the part of the ring across it, and on both sides of this spectrum the spectra of the ansæ

The planet was kept upon the same part of the slit with sufficient exactness to keep these three spectra distinct and from encroaching upon each other, and therefore if any difference existed between them, it could be detected.

The exact correspondence of the Fraunhofer lines in the spectrum of the planet and its rings with those of the sky spectrum is clearly shown, but I am unable now, as I was in 1881, to detect any lines, dark or bright, other than those which are also present in the sky spectra. The spectrum on the plate extends from a little above F to beyond N in the ultra-violet.

I am trying to obtain enlargements of the spectra of Saturn and Uranus to serve as illustrations to this note. If they can be done so as to admit of reproduction, I will do myself the honor to present them to the Royal Society.

[We have observed since, the visible spectrum of Uranus, but under unfavorable conditions, the planet being low and the sky not dark. These observations confirm me strongly in the opinion I formed in 1871, that the brighter parts of the spectrum appear so as an effect of contrast, and do not represent emitted light. In the moments of best vision the spectrum on both sides of brighter parts appeared to be darkened by groups of lines which give a heightened effect by contrast to the less obscured parts between them. At moments we were conscious of dark lines crossing the spectrum, but the unfavorable conditions under which the observations were made prevented us from ascertaining, by measurement or otherwise, whether any of these lines were Fraunhofer lines.—July 5.]—*Sidereal Messenger.*

* 'Untersuchungen uber die Spectra der Planeten,' Leipzig, 1874.
† Measures of some of the bands were made at Greenwich in 1882. See 'Greenwich Spectroscopic and Photographic Results,' 1882, p. 33.
‡ 'Phil. Trans.' 1880, p. 669.

PROF. D. E. HUGHES, F.R.S.

WHATEVER may be the merits of the controversy of prior discovery, we have always held Prof. Hughes to be the man who made telephony practical. He it was who, working with the simplest materials in a direction that to most people looked uninviting, showed how what had previously been looked upon as a great evil was in reality a greater blessing.

Prof. Hughes nobly gave his investigations to the world; others reaped pecuniary rewards, but so long as humanity endures, so long will the thanks of civilized people go to the man whose portrait we have the pleasure of giving to-day.

Prof. Hughes merits all the praise his *confreres* can give him. He has done good work in a double capacity. As a mechanician his devices in applying electricity have never been equaled. As an investigator his discoveries have made his name a household word. It is hardly for us here to speak of a still higher position he holds as a firm and faithful friend. The many who know and are known to him will anticipate all we could say in this direction, and agree that the sweetest words would still be harsh music to sing of one whose presence always delights and whose friendship is always sincere.

Prof. Hughes is a Londoner, born in 1831. His parents emigrated to America when he was only seven years of age, and where, before he reached his majority, he had already made his name as a musician.

The world must be thankful, however, that his abilities were turned in other directions, and his proficiency in physical and mechanical science transferred him from the chair of the professor of music to that of natural philosophy.

It was while professor at the College of Bardstown, Kentucky, that Prof. Hughes turned his attention to the application of electricity to telegraphy. How well he succeeded we all know; for although his instrument did not meet with much favor in England, it was largely used in America, and adopted in most Continental countries.

Welcomed and decorated everywhere, except by the land of his birth; but he understands our phlegmatic temperament, and that though Englishmen are not usually prone to hero worship by means of titles and orders, they are sound to the heart's core, recognizing the man a prince among them, honoring him individually, and appreciating the merits of his works.

As we have previously mentioned, to Prof. Hughes we owe the microphone and many of its ingenious de-

D E Hughes

velopments. Upon his researches into magnetic phenomena we will not dwell. They should be as the alphabet, well known.

Prof. Hughes represented England at the 1881 exposition at Paris. He is a fellow of the Royal Society, and has received the Royal medal for his electric and magnetic researches. He is one of the past-presidents of the Institution of Electrical Engineers, having filled the office of president in 1886.

With these few words we must leave the subject of our sketch, though, to quote a line of Hunt's, we might speak of him as essentially "One who loves his fellowmen."—*Electrical Engineer.*

SOME RECENT SPECULATIONS ON THE ORIGIN OF PETROLEUM.

THE distinguished Russian chemist Prof. Mendeleef, of St. Petersburg, has recently discussed from a new standpoint this oft-mooted question, and, as considerable currency has been given to his theory, this fact, together with the eminence of its author as a chemist, renders some notice of it appropriate to these pages.

In his essay Prof. Mendeleef sets out with the statement that most writers tacitly assume that petroleum is a product of vegetable matter. For this assumption there is, he says, no ground unless we admit that its chemical composition—resembling coal so closely as it does—may be admitted as an argument. This origin he sets himself to disprove. Petroleum could not, he says, have been produced on the surface because it would have evaporated. Nor could it have been produced over a sea bottom, because it would have floated up and have passed off. Thirdly, he maintains it must have been formed where it now exists, because it could not have been transported as sand or clay, and could not have flowed on the surface.

Now with all respect to the eminent attainments and brilliant reputation of Prof. Mendeleef, we may say at once that this catalogue does not by any means exhaust the list of possibilities. There are situations in which petroleum may have been made other than the surface and the sea bottom. Indeed, we have never heard the former advocated by any one. And granting, for the sake of argument, that petroleum cannot be transported very far, yet Prof. M. adduces no satisfactory evidence against its formation in the region in which it actually occurs.

We must assume that Prof. M. has some practical acquaintance with the geology of the Baku oil regions of Russia, but we cannot refrain from suggesting that he does not show the familiarity with similar districts in North America that would be desirable in one who undertakes to propound a new theory on so difficult a subject.

According to his statement, the oil-bearing strata of Europe belong chiefly to the Tertiary or later ages. He therefore admits that the carboniferous deposits beneath them may possibly be the source from which their oil has been derived. But he adds that the oil bearing sands of North America belong to the Devonian or the Silurian strata, in which few or no organic remains have been found. If the coal measures were the source of the oil, it would never, says he, have gone down into the underlying Devonian rocks of Pennsylvania through the intermediate shales and clays. So that it is not possible to attribute its origin to the secular changes produced in coal by heat and pressure.

It seems incredible that such a statement can have been made by any one acquainted with the abounding fossils of these rocks in Canada and the United States, where whole layers consist in some places of almost nothing but the relics of bygone life, both animal and vegetable. This is the case with many beds in the Trenton and Hudson River groups. The Devonian rocks in the eastern and midland States are also filled with similar remains, especially of marine invertebrata and fishes, while some strata of this latter system in places consist of little save the minute sporanges of aquatic cryptogams, indicating an abundance of these plants at that date which it is difficult to realize.

The prevalent opinion among geologists is that petroleum results from the slow secular changes that take place spontaneously, as it were, in such masses of organic matter as we have just indicated. Sea weeds and plants of their low grade leave, in most cases, no distinct fossil remains, but their decay produces a quantity of bituminous material which may be represented merely by the black carbonaceous substance of the shales. It is only when, as in Ohio, such shales containing more or less bitumen in their mass are overlaid by a porous sandstone and that in turn by an impervious layer of shale that the conditions are fulfilled and a store of gas or oil results. A porous limestone may take the place of the sandstone and a bituminous limestone may play the part of the shale, as in northern Ohio, but the general conditions remain unchanged, so that there is in reality no need to look for any other source of petroleum.

Mr. W. Anderson, in his presidential address to the Section of Mechanics of the British Association at Newcastle-on-Tyne, developed to his audience Prof. Mendeleef's theory, and apparently with approval. In his sketch, which is somewhat hypothetical, he follows his leader in presupposing as a necessary condition the existence of iron in immense quantities in the interior of the earth, both pure and in the form of carbides. Water penetrating the crust is supposed to react on these substances and so to develop a hydrocarbon at the expense of its own oxygen. The new hydrocarbon thus produced is carried up with the steam into which the water has been transformed and deposited as soon as the cooler strata are reached.

It is scarcely necessary to mention that the data here assumed are not only unproved, but highly improbable. In fact their assumption almost amounts to a return to the old hypothesis of Sir Humphry Davy, who in his enthusiasm at having discovered the remarkable properties of potassium, imagined a vast storehouse of his new metal in the bowels of the earth, by the aid of which he could explain all the phenomena of volcanic action on chemical principles.

Prof. Mendeleef further endeavors to support his theory by asserting that oil-bearing regions always lie near to or run parallel with mountain ranges, as in the case of the Appalachians and Caucasus. In the synclinial cracks, widening below, which he says must exist in such regions, lie the accumulations of oil and gas. Now it is well known in America that a fissured region, especially a synclinal, is barren ground, and that a disturbed region is also devoid of oil and gas. Both occur only in strata almost horizontal and usually along lines of very slight anticlinical arching. So that geology affords no ground whatever for the new theory.

Moreover, there are exceedingly productive districts in the western hemisphere, such as those in Indiana, in Ohio, and in Ontario, where there can be no such fissuring as is required by Prof. Mendeleef. The regions in question lie at a distance from all mountains and all disturbance capable of producing fissures and in the midst of a wide extent of nearly horizontal and uncontorted rocks not varying from the level more than a few feet in a mile. All the chief data required for the new theory are conspicuously absent.

Finally Prof. Mendeleef seems to depend largely for the support of his theory on the enormous quantities and high pressure and permanence of the oil and gas supplies. This he uses as a powerful argument against the belief in their derivation from any organic source, such as the bituminous shales of the secondary or even of the Palæozoic rocks. This abundance indicates, he thinks, an origin in chemical action in the primary nucleus of the earth or in the deeper parts of the crust. This doctrine would be welcomed by all those whose money is in gas and oil, and would be indeed joyful news to all who have hoped to be delivered from the plague of smoke by the advent of natural gas. But we can assure Prof. Mendeleef that this last hope will prove fallacious, and that how abundant soever may be the present supply, that supply is destined to fail, and before very long. The new oil and gas region of the Caucasus may not yet show sign of failure, and years may pass before such sign appears, but the falling off of the spouting and flowing wells, which is as constant there as elsewhere, and the need for pumping where the yield was once spontaneous, are indications that cannot be mistaken; and as the great gushers of Pennsylvania have long since ceased to flow, so the enormous supplies elsewhere will one day follow suit.* Economy is the wise policy of all engaged in the manufacture, in order that the wonderful store of natural fuel, liquid and gaseous, may last as long as possible. Signs are abundant that the quantity is limited, and that if produced now at all, the production is far slower than the consumption. Apprehension is already felt that the great blowers of gas at Pittsburg are running down, and such announcements as the following are not calculated to allay the feeling:

"That the gas supply in this (Pittsburg) district and adjoining places has passed its zenith and is now on the wane can no longer be satisfactorily denied. The reason usually given was that new mains were being laid to the wells or that the size of those already down was being enlarged. These changes have all been made, and still the desired fuel does not pour through in the necessary quantities. This state of affairs was noticed first in the latter part of last winter, but the coming of warm weather relieved the pressure for domestic purposes and nothing was heard of the shortage during the summer months. But with the first appearance of a change of temperature this fall the trouble recommenced in an aggravated form. The last movement of the natural gas companies has been to ask the big mills to run only at night, when the demand for

* See an article on "The Future of Natural Gas" in the *American Geologist* for January, 1888, where this state of things was distinctly foretold.

fuel for other purposes would be slight. Many of the establishments have decided to return to the use of coal, and some have already done so."*—*Philadelphia Enquirer*, Oct. 15, 1889.

In the conclusion of this address Mr. Anderson remarks: "We are almost forced to the belief that the hydrocarbon products must be forming as fast as they are consumed, and there is little danger of the demand ever exceeding the supply, and that there is every prospect of oil being found in almost every portion of the surface of the earth, especially in the vicinity of great geological disturbances. Improved methods of boring wells will enable greater depths to be reached, and it should be remembered that, apart from the cost of sinking a deep well, there is no extra expense in working at great depths, because the oil generally rises to the surface or near it. The extraordinary pressures, amounting to 300 pounds on the square inch, which have been measured in some wells, seem to me to yield conclusive evidence of the impermeability of the strata from which the oil has been forced up, and tends to confirm the view that it must have been formed in regions far below any which could have contained organic remains."

After what we have already said, it is needless to point out the fallacy of Mr. Anderson's reasoning and the baseless nature of the rose-colored vision with which he amused his audience in the latter part of his discourse. No gas or oil well has ever been known to afford a pressure greater than that due to its depth, or indeed equal to it. No oil well has flowed except in diminishing quantity even for a few years, nor has the oil permanently reached the surface. Nor does the ability of reaching greater depths afford us any hope. Already the wells are far below all the productive strata.

Three thousand and even four thousand feet have been penetrated, and the ancient gneissic rocks have been reached in the United States, while in Germany even this has been surpassed, and the auger has been down 5,000 feet below the surface, and the latest report gives the actual deepest boring at 5,735 feet, or considerably more than a mile. But the lowest oil-bearing strata in North America are only about 1,500 feet down, and it is rare indeed to find any valuable yield below that depth. In the Caucasus the beds are, we understand, even nearer to the surface. All analogy and all probability are, therefore, against the chance of our ever finding gaseous or liquid fuel at great depths in the crust, and the idea of going down below the Palæozoic strata in search of oil or gas in the hope of winning them from the old Archæan rocks below can find no place in the mind of any one of sound judgment and practical experience in the subject, be he chemist, geologist, or only well sinker.—*Amer. Geologist.*

THE BABYLONIAN METRICAL SYSTEM.

AT a recent meeting of the Berlin Physical Society, Dr. Lehmann spoke on the nature and distribution of the Babylonian metrical system. He expressed his desire to lay before the competent judgment of the physical society the results of his most recent archæological researches, so far as they are of direct physical interest, and then proceeded to describe the numerical system employed by the ancient Babylonians, explaining that it consisted of a sexagesimal system with decimal subdivisions. The unit of time, the double-minute, was the time occupied by the sun's rising, measured at the equinox, and could thus be recovered at any time.

It was measured by the mass of water which flowed out of a certain vessel from the instant at which the upper edge of the sun appeared above the horizon to the moment at which his lower edge was exactly touching the horizon. The day consisted of 720 of these units. The unit of length was the ell, which was used in two forms, either as a single or double-ell; sub-divisions used were the foot = ½ double ell, the hand width, and the finger length. The unit of weight was the mine, also occurring as single mine or double mine. The derivation of units of weight from units of length, as in the modern case of grammes and centimeters, was also known, but of course the water used was not distilled and was not weighed at 4° C.

The speaker had, however, succeeded in discovering a measuring scale on an ancient monument dating from the year 2500 B. C., which had enabled him to compare the Babylonian measures with those of our own time. It appeared from this that a hand breadth = 99·4–99·6 mm.; a double-ell = 994–996 mm.; and the foot = 331–332 mm.

He had further discovered several stamped weights, and thus found that the double mine = 982·4–985·8 grammes. The single mine weighed half as much as the double mine, but the gold mine and silver mine were equal to five-sixths of a single mine. The royal mine was 1 per cent. heavier than the gold mine, and was employed for the payment of tribute. The coinage was based upon the mine and its sexagesimal division.

Dr. Lehmann remarked how surprising it is to find that the length of a seconds pendulum at Babylon is 993·5 mm., and was inclined to advance the hypothesis that the Babylonian unit of length was derived from a seconds pendulum, the foot being one-third the length of the pendulum. He next proceeded to give an account of the spread of the Babylonian mine, and of the Phœnician, which was derived from it, as a unit of weight among the civilized nations of Europe.

The discovery of an old Roman balance had enabled him to determine that the old Etrurian pound was equal in weight to the Babylonian mine. The Babylonian unit of weight is found not only in Italy and the Mediterranean generally, but also the old Dutch and French pounds and the Russian pood are equal in weight to the mine. The speaker considered it to be quite impossible that in all the above cases we are dealing with a chance correspondence between the several weights.

In the discussion which ensued, objections were raised on several sides against the hypothesis that the ancient Babylonians had knowledge of the seconds pendulum, which had subsequently been lost. On the other hand, it was pointed out by others that the ancients were not improbably acquainted with the plummet, and used it for squaring stones, etc.; and since, further, they employed the double minute as unit of time, it is not impossible that they were acquainted with the seconds pendulum.

The cause of their not having employed this instrument to supply a time unit may perhaps be found in their ignorance of any means by which the pendulum could be kept in continuous and uniform motion. In conclusion, the speaker laid stress on the high state of culture which the Babylonians had attained three thousand years B. C., and expressed his regret that a complete blank exists with regard to everything of an earlier date than the cuneiform inscriptions.

THE NEBULÆ.

IT is clearer than ever that the nebulæ are not "distant galaxies" far beyond the stars. They are not clusters of full-sized stars, which appear nebulous only because of their inconceivable remoteness, but they are *clouds*, and their luminosity is due to shining gases, among which hydrogen is present, though the gas which furnishes the brightest light remains still unknown. Moreover, these clouds, whatever else they may contain besides the luminous gases, are somehow kindred to the stars, and associated with them in such a way as to suggest almost irresistibly that the nebula is the material out of which stars are made.

The question of their permanence remains unsettled. It is altogether probable that processes are going on within them which slowly alter their conditions, but time alone can determine the rate and nature of such changes; the evidence, as yet, is indecisive.—*Prof. C. A. Young, in Popular Science News.*

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* We find that the same complaint comes from Wheeling, W. Va. In the issue of the SCIENTIFIC AMERICAN for October 5, which has just come to hand, we read, "The natural gas supply is becoming scarcer every day, and there is especial complaint among the manufacturers, who had hoped that during the warm weather they would have all the gas that they needed. For several weeks past the Riverside Tube Works and Plate Mill have been greatly troubled by lack of gas, and at times have been compelled to stop till the supply became better. The company is getting things into shape as rapidly as possible to go back to the use of coal in the tube works. The Bellaire Mill has gone back to the use of coal, and the Labelle is understood to contemplate a return to coal in all departments. Several other mills and factories are in the same position."—*Register.*